ESSENTIALS OF
ORTHOPÆDICS

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By

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PREFACE TO THE SECOND EDITION

ORTHOPÆDIC SURGERY progresses slowly and it was only after begin-ng to prepare a second edition that I appreciated the extent of the ange that has taken place during the five years since the first edition was blished. Revision has, therefore, taken longer than was anticipated. As before, I have tried to confine myself to the elements of the subject, th physiological and pathological, and their application to diagnosis d treatment. The addition of some fifty pages is due as much to the troduction of new ideas about old problems as to the inclusion of entirely w material, and although most of the rare diseases are mentioned, they e discussed as briefly as possible. Operative details of interest chiefly the specialist are deliberately left out, and the many technical advances the last few years are introduced only when they have a bearing on ognosis.

Every page has been corrected or revised and there is not a chapter ithout major alterations to several sections. Many of the old illustrations ve been replaced by better examples, a few have been omitted and about irty new figures have been added. Amongst the sections that have been written are those on the etiology of postural defects; the etiology, assification and treatment of pain in the back; the treatment of sciatica nd of scoliosis; the investigation and treatment of congenital dislocation f the hip; the etiology and treatment of osteoarthritis of the hip and the nee; chondromalacia of the patella; cervical spondylosis; ischæmic con-acture; osteomalacia and renal osteodystrophy; and the classification nd terminology relating to tumours of bone has been brought up to date. The chapter on pain in the back has been the most difficult to write ecause there is still so little precise knowledge of the etiology; several ew ideas which seem to be soundly based have, however, been introduced, nd the popular notion that most complaints can be explained in terms of "slipped disc" has been steadfastly resisted. The treatment of tuber-ulous disease of bones and joints, which is being revolutionized by anti-iotics, has also been difficult because, at the time of writing, the new path not clearly defined and it has been possible only to indicate its direction.

I must again pay tribute to my teachers, Sir Gordon Gordon-Taylor ho first introduced me to surgery, Lord Webb-Johnson whom I had the rivilege of serving as first assistant for three years, and the late Mr. A. S. . Bankart to whom I was apprenticed in orthopædic surgery—three reat surgeons and fine men; as the years pass, I appreciate my debt the nore. And I owe as much to my contemporaries and colleagues for all hey have taught me, especially the members of the W. J. Little Orthopædic Club—H. Jackson Burrows, H. Osmond Clarke, Derek Coltart,

A. T. Fripp, Herbert J. Seddon, T. T. Stamm, Reginald Watson-Jones, and the late V. H. Ellis—some or all of whom have met for intimate discussion each winter month for nearly twenty years.

The manuscript of the first edition was read and freely criticized by a number of my friends on the staffs of London Teaching Hospitals. On this occasion there has been insufficient time to seek their help again and it is only the sections on tuberculous disease, with which Mr. H. J. Seddon has been so kind as to help me, that have been submitted to criticism.

My colleagues have again been generous enough to make available a number of illustrations and it is with great pleasure that I thank Mr. St. J. D. Buxton for Fig. 344, Mr. J. A. Cholmeley for Fig. 71, Mr. W. D. Coltart for Fig. 377, Sir Thomas Fairbank for Fig. 378, Mr. J. I. P. James for Figs. 76, 77 and 78, Dr. Leo Mayer for Fig. 30, Dr. Ali Mohammed for Fig. 316, Mr P. H. Newman for Figs. 297, 299 and 392, Mr. K. I. Nissen for Fig. 190, Prof. R. W. Scarff for Fig. 275, Mr. H. J. Seddon for Figs. 91, 92, 94, 114, 124, 172, 173, 280, 319, 320, 321, 323 and 356, Dr. P. H. S. Silver for Figs. 2 and 44, Dr. F. H. Stevenson for Fig. 174, Sir Reginald Watson-Jones for Fig. 358, Mr. M. C. Wilkinson for Fig. 93, and Prof. B. W. Windeyer for Fig. 357.

Finally, I wish to thank Mr. M. Turney [illegible] his staff in the Photographic Department of the Middlesex Hospital for their skill in preparing the radiographs for reproduction, and Mr. Rodney Sv[illegible]n for the care with which he has corrected the proofs.

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PHILIP WILES

PREFACE TO THE FIRST EDITION

NICOLAS ANDRY, in 1741, wrote a book which he called *L'Orthopædie* because it was about the problems of "straightening children," and the term has remained in use ever since. It is, however, an imperfect description of the work of the present-day orthopædic surgeon as this includes all diseases and injuries of bones and joints, and of the muscles and nerves controlling them. The field has become so vast, even when fractures are excluded, and much is so specialized, that no single volume could cover all aspects. I have, therefore, endeavoured to explain as simply as possible the physiological and pathological basis of orthopædics and its application to diagnosis and treatment. The increasing appreciation of the importance of posture has made it desirable to pay special attention to this subject.

I have had in mind primarily the needs of the general practitioner who has to advise the patient in the first instance, the undergraduate student who requires classified information to help him order his thoughts, and the postgraduate who is beginning his surgical training. A regional arrangement is used in order to assist with diagnosis, and when a disease occurs at several sites, the pathology is considered either with the region at which it is most common or in a separate chapter. Treatment is described in detail when it can be carried out by a general practitioner; in other cases the available methods of treatment and the probable functional results are discussed, operative procedures being described only in general terms.

The foundations of modern orthopædic surgery were laid less than a generation ago by a small band of pioneers, and between these men was formed a bond of fellowship that knew no international boundaries. We are proud that now, when orthopædic surgeons are numbered by thousands instead of by tens, this fellowship remains and there is still the free-est interchange of ideas and experiences between one surgeon and another, and one country and another. It is well that this is so because orthopædics is still in its infancy and there is hardly a procedure that is universally accepted as "best," or that someone, somewhere is not trying to improve. Progress has been particularly rapid in the U.S.A. during the last decade, and in spite of difficulties in communication during the war, many of the new developments have been adopted by British surgeons. There remain, however, a few major differences in the current practice of the two countries, and this is a healthy sign of the mutual criticism that is not only tolerated, but encouraged.

Orthopædics differs from other branches of surgery in that it deals chiefly with injuries and diseases that are potentially crippling. The major role in treatment has often to be played by the patient who alone can

prevent his joints from becoming stiff and his muscles from wasting. It is, therefore, essential to have the whole-hearted co-operation of the patient and, equally important, the help of a team consisting of nurse, physiotherapist and social worker to stimulate and direct his efforts. The purpose of operation is to make it possible for the patient to do his share of the work; it is but an incident in the course of treatment, and if its part is over-emphasized in the written account, it is because it would be tedious to repeat the other aspects continually even though they are just as important.

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CHAPTER I

POSTURAL DEFECTS

POSTURAL defects are variations from the accepted "normal" posture which can be corrected by the active effort of the patient. It is seldom that one part of the body alone is involved and usually the entire posture is at fault; for example, valgus feet are found more frequently in association with abnormalities of the antero-posterior curves of the spine than as an isolated occurrence. The inter-dependence of defects of different parts of the body will be emphasized as much as possible although they have to be separated for systematic description, and when considering treatment it is particularly important to view the patient as a whole because a single fault cannot be corrected alone.

There are several minor structural abnormalities that are so commonly associated with postural defects as to be inseparable, and therefore they will be described in this chapter. They include slight wedging of the lower dorsal and upper lumbar vertebræ (dorsolumbar kyphosis), torsional deformities of the tibiæ, and obliquity of the lower articular surfaces of the tibiæ. Knock knee and bow legs are also included because they are often caused by a minor irregularity in growth or faulty posture.

Physiology

The posture of the body at any given moment depends on the position of the joints and this is controlled by the skeletal muscles. The part played by the ligaments in maintaining posture is a subject of controversy. It is argued by some that the strength, structure and arrangement of the ligaments make it obvious that it must be an important part. On the other hand it is clear that in the ordinary upright position no ligaments are under tension because every joint is at an intermediate point in its range of movement and can be moved in all directions. Ligaments are so nearly inextensible that, if they were taut, movement would be impossible in at least one direction. Moreover continued strain on ligaments is painful, as everyone is aware from the pain felt behind the knees after resting the feet for some time on the opposite seat in a railway carriage. For these reasons ligaments can play no direct part in holding the upright position. Their function is complementary to that of the muscles; the muscles cause movements and maintain posture within the ordinary range, whereas the ligaments limit the extremes of movement and take the strain when the muscles are fatigued or overloaded.

The apparent paradox that muscles both cause movement and prevent it is not difficult to explain. When a muscle fibre is stimulated it

develops within itself a state of tension and its subsequent behaviour depends on conditions external to it. If there is no resistance, the fibre contracts and causes movement; if there is resistance which it is unable to overcome, movement is absent or minimal and the contraction is said to be "isometric." The former process is used in making movements, the latter in maintaining posture. Individual fibres follow the "all or none" law and therefore the power exerted by a contracting muscle is proportionate to the number of fibres in action. This in turn depends on the external resistance to be overcome and the rapidity of movement. For the maintenance of posture, the number of fibres in use simultaneously is small and there is a continual change of contracting fibres which reduces fatigue to a minimum (Fig. 1).

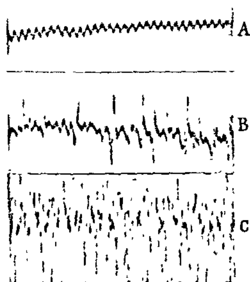


FIG 1 Electromyogram of the gluteus medius muscle Intramuscular electrode Photograph of oscillations of a cathode ray tube
A At rest
B Standing on both legs
C Standing on one leg

When standing upright the body is not quite in a state of balance. There is a continual but very slight sway at the ankles which is corrected by the flexor and extensor muscles contracting alternately (Fig. 2). A larger change of balance, say moving the hands forwards an inch, displaces the centre of gravity sufficiently for a compensatory contraction of the erector spinæ to be detected. More complicated movements call for correspondingly elaborate integration. The regulation of the process is carried out by the central nervous system which receives afferent impulses from the muscles, eyes, ears and skin. But before this information can be translated into efferent motor impulses, it must be integrated with the habits of stance and movement of the particular individual concerned. Posture thus becomes a psychosomatic phenomenon determined by the brain and executed by the muscles.

The posture of an individual is best considered in relation to the concept of "body image" introduced many years ago by Henry Head to convey the idea each person has of his *own* body (and that can be quite different from the ideas others have of it). It is a very personal affair which is

constructed from information derived from intrinsic sources and related to the environment, both objective and subjective. The principal intrinsic sources are visual impulses, tactile impulses and proprioceptive impulses. Visual information about ourselves is peculiar in that we see ourselves, for the most part, either in reflection or else upside down; we relate it to the right-way-up appearance of other people. Tactile impulses tell us what we feel like and this is different from the feel of others because it is felt simultaneously by both the touching and the touched parts of the body. Proprioception is perhaps the most important of these percepts. It is

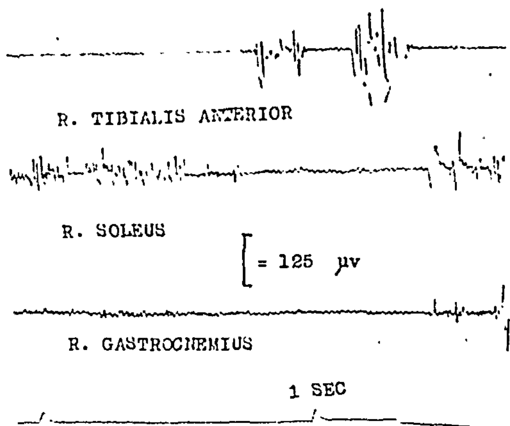


FIG 2 Electromyogram from a man standing still Surface electrodes, ink writing oscillograph
The reciprocal action of the anterior and posterior calf muscles is well shown
(By courtesy of Dr P H Spencer-Silver)

entirely personal without possibility of relation to the experience of others, and it is unconscious. It gives information as to the movements of joints and the relative length of the controlling muscles, hence of position in space.

The body image can be extended to include a certain amount of extra-personal space; thus the touch-typist comes to include the keys of her machine. Blake Pritchard gives the example of the experienced driver whose image extends to the tips of the wings of his car, whilst that of his passenger very definitely does not! The body image of those born blind, or without a limb, or with spastic paraplegia, is obviously different from that of a normal person, and even small variations in physique must modify it to some extent. Modification arising from the individual's

environment are equally important. In fact, the body image is really a component of the personality; and conversely the personality is reflected in the body posture, just as it is in the person's clothes. In other words, posture and personality are completely interdependant.

The body image develops slowly from earliest childhood and changes continuously during growth. The information derived from proprioceptive impulses can remain static only for the briefest time because of the constantly changing balance of the muscles and other soft tissues. Growth of the limbs and trunk is induced entirely through the agency of the bones. Bones have an intrinsic power of growth, and do so in almost any medium, whereas the soft tissues—periosteum, muscle, tendon, fascia and skin—grow in length only in response to the "stretching" effect of the growing bone. The proprioceptive information derived from these tissues must, therefore, require continual adjustment to yield accurate information as to posture.

The mental record of the body pattern has been termed by Head the "schema." It is by reference to the schema that posture is appreciated and the complicated adjustment in the balance of the many muscles that accompany even a simple movement is achieved. The schema may be likened to the perforated record of a pianola which plays a tune determined by the position and shape of the perforations. During growth the schema is continually being modified—the perforations in the record are always changing. In other words, the postural reflexes are subject to continual adjustment. It is only when growth has ceased that posture becomes comparatively stable, and even then it may be changed by major modifications in physique or personality.

To sum up: posture depends on the position of the joints and this is determined by the skeletal muscles which are themselves controlled by the nervous system; the habitual posture is a reflection of personality as well as physique. The muscle power used in maintaining posture is small and muscular weakness alone does not affect posture.

Ætiology

It has been customary for many years to lay the blame for some postural defects, and indeed for gross deformities, on the immediate surroundings of the child, such as vicious school furniture, and the type of clothing. The older textbooks contain delightful woodcuts showing, for example, a child with a severe structural scoliosis playing the violin, and a schoolgirl slouching over a badly designed desk with her head resting on one hand. It is naively assumed that these figures illustrate the cause of the deformity but no explanation of the mode of action is offered. It is difficult to believe that such factors are of great importance; a child who is going to sit badly will do so at any desk and it would be far more rational to blame a boring lesson which fails to hold his attention. The modern approach is admittedly speculative but it does take into account the relevant physiology, and it does offer a basis for rational treatment.

Postural defects occur when the postural reflexes do not conform with

the accepted standards. The account already given of the development of these reflexes suggests that defects will arise most often during periods of rapid growth and at times of emotional uncertainty. This is in fact the case. It is seldom easy to be sure of the precise cause in a particular child but occasionally it is clear, for example when there is an upset in general well-being such as occurs in the undernourished, or in toxæmia due to chronic infection. Nor are the psychological factors usually obvious because the emotional disturbance is seldom gross. More often there is but a trivial and temporary mal-adjustment, or perhaps just a lack of interest in the particular phase of development.

Children have much to learn and tend to concentrate on one aspect of life at a time. Whilst a young child is busily enquiring about the many phenomena surrounding him, and being well satisfied with the mobility given by his recently acquired powers of locomotion, he may lose interest in the way his body functions. But at a later period, perhaps when games are interesting him, he will all unconsciously attend to the defects of the body that may have developed meanwhile. Girls in their early teens frequently stand badly and are ungainly in their movements, and it is noticeable that the age at which they correct themselves often corresponds with the first display of real interest in the other sex.

Gross psychological disturbances occasionally appear to be responsible for the development of postural defects and it does sometimes seem possible to make a direct correlation between the emotional and the physical condition. The most extreme example is seen in "neurasthenia," using the word in the narrow sense of a particular functional nervous disorder. The picture in both adults and children is distinctive. The patient is flabby in mind and body ; mentally he is tired, bodily he has given way to gravity and has a sagging jaw and drooping eyelids, rounded shoulders, a tilted pelvis and flat feet. The mental and physical condition go together and any attempt to change the physical condition until such time as the psychological adjustment has been improved leads to disappointment.

There are other less clearly defined groups. In the "anxiety state" the general picture is of a hypersensitive, alarmed child, not infrequently subject to nightmares and sometimes with a stammer. Physically he tends to have valgus feet, knock-knees, and round shoulders—a position of fear—but in contrast with the "neurasthenic" his muscles are tense rather than slack. Again, the "obsessional" child may have queer habits of gait and posture, often asymmetrical, which are impossible to explain except in association with the psychological condition. Most patients do not, however, show so extreme a picture and the correlation between the physical and psychological findings is seldom obvious.

The implications as regards treatment are clear. It must be directed not to the muscles, but to the central nervous system that controls them. Most defects will be corrected spontaneously whether treatment is given or not. Active attempts at correction must be designed to change the postural habits, and this is possible only when the child is sufficiently interested, and when his emotional condition is secure.

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Postural defects occur when the postural reflexes do not conform with

and 28° in females. Variations up to 4° on each side of the average is within the "normal" range. The pelvis is more horizontal in infants and the inclination increases steadily with growth: at four years of age it is about 22° in both sexes, and at seven years 25°. The adult angle is reached about the tenth or eleventh year and then the variation due to sex first appears.

Another feature that can be measured is the relation of the large joints to the plane of the centre of gravity of the body. The true centre of gravity lies a little to the front of the second sacral vertebra. The plane passing through the mastoid process lies close enough to this point to be accepted for clinical purposes as the plane of the centre of gravity. Normally it passes through the middle of the shoulder and hip joints, towards



FIG 4 The posture of young adults

the front of the knees and well in front of the ankles (Fig. 4). Deviation from this alignment occurs with certain postural defects.

The curves of the spine of different individuals, when viewed from the side, often look dissimilar even when they are actually the same. For example, if the sacrum is placed more horizontally than usual (and the angle varies considerably), the buttocks are more prominent and the lumbar curve appears to be increased. Similarly, if the scapulæ are placed rather anteriorly, the dorsal curve seems to be more pronounced. The actual curves of the spinal column may also be masked by an increased development of the erector spinæ, or hidden by subcutaneous fat.

Normal Posture

The posture of different individuals varies within wide limits according to body build, habits and occupation; moreover posture is as much an expression of personality as the gestures of the hands. There is no normal posture any more than there is a normal body weight, and the concept of an average posture, a mathematical mean of all postures, is valueless. We can only describe certain outstanding features, some of which can be measured, and make allowance for individual variations. The finer points that go to make a good "carriage," such as the poise of the head and neck, are too elusive for mensuration and the final assessment must remain to some extent a matter of personal judgment and experience. The printed silhouettes showing "normal" posture that are sometimes displayed should be interpreted with indulgence.

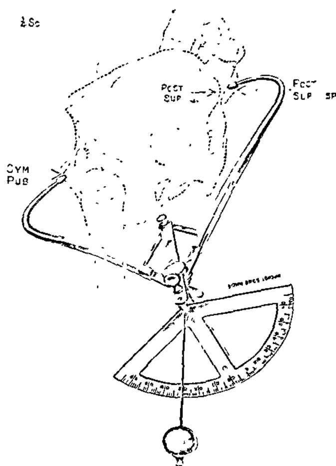


Fig 3 Wiles's pelvic inclinometer

The posture of the hip joint is the key to that of the whole body because it determines (*a*) the inclination of the pelvis, and the pelvis is the foundation upon which the spinal column is erected, and (*b*) the rotation of the legs and therefore the posture of the feet (p. 21).

The pelvis is irregular in shape and there is no general agreement as to the selection of points to indicate its inclination. Various suggestions have been made but none readily give the plane either of the pelvic brim or of the upper surface of the sacrum. For the present purpose it does not matter what plane is used because it is required only for comparative purposes. The following method of measuring the pelvic inclination uses arbitary points selected chiefly because they are easily palpable, and it is rapid and sufficiently accurate. The points used are the upper border of the symphysis pubis and the posterior superior spines of the ilium; one blade of the inclinometer is placed on a mark made in the mid-line at the level of the posterior superior spines, the other is placed on the upper border of the symphysis, the instrument is adjusted to make the plumb-bob parallel with the plate and a reading is made (Fig. 3).

The pelvic inclination measured by this method averages 31° in males

Movement of the spine is greatest in the lumbar region where there is a large and powerful muscle mass to raise the trunk from the flexed position. In the dorsal region rotation is considerable, but flexion and extension are restricted. The dorsal spine, however, extends slightly but appreciably with every breadth, and therefore the muscles of respiration, the diaphragm, intercostals, etc., have a secondary postural rôle.

Thoracolumbar Kyphosis. This is a localized form of adolescent kyphosis in which the bodies of the lower thoracic and upper lumbar vertebræ become slightly wedge-shaped (Fig. 6). The condition commonly accompanies certain postural defects and possibly is caused by them. The abnormal posture increases the stress on the anterior portions of the



FIG 6 Thoracolumbar kyphosis. There is wedging of the 11th and 12th thoracic and 1st lumbar vertebræ

vertebral bodies and intervertebral discs, and this may interfere with their development (p. 95). The thoracolumbar region, where the alteration in curve from concave to convex makes it mechanically weaker than the rest of the spine, is the site at which such changes occur most frequently.

Types of Defect

It is essential for the maintenance of the upright position that whatever abnormality of posture is present, the centre of gravity of the whole body is above the area occupied by the feet. This limits considerably the possibilities of postural variation. In the following descriptions it is assumed that the pelvic inclination alters first and then movements of the rest of the body are made afterwards to adjust the centre of gravity. This makes the mechanics clearer and is helpful in planning the details of treatment, but it is not the actual manner in which defects arise during life ; the process is one of gradual "slumping" rather than separated movements.

ANTERO-POSTERIOR CURVES OF THE SPINE

The pelvic inclination is the most important single factor affecting the curves of the spine. The pelvis is the base upon which the spinal column is erected and therefore any change in its inclination must cause a corresponding change in the position of the fifth lumbar vertebra, and this in turn alters the posture of the whole spine.

The pelvis is balanced on the femora, hence its inclination is determined by the posture of the hips (Fig. 5). Control of the pelvic inclination is exercised ordinarily by the muscles surrounding the hip and only in unusual circumstances is it a function of the trunk muscles. The inclination is increased by contraction of the flexors of the hip, i.e. the ilio-psoas, rectus femoris and the more anterior portions of the adductors. It is decreased by the extensors, i.e. the glutei, hamstrings and posterior adductors. The three glutei function in one unit as part of the extensor group of muscles that maintain the upright position.

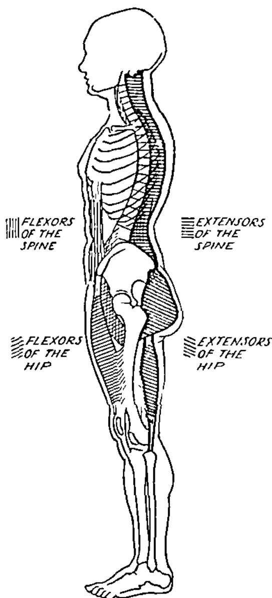


Fig 5

Their combined unopposed action produces extension, abduction and external rotation of the hip joint, the thigh or pelvis being moved according to which is free; the thigh moves during locomotion, but the pelvis when standing. Postural increase in the length of the glutei allows the pelvis to tilt forwards and the legs to rotate inwards.

The spine is extended by the erector spinæ and flexed by the abdominal muscles. It is sometimes stated that contraction of the rectus abdominis reduces the pelvic inclination and patients are wrongly taught to use this muscle for the purpose. The rectus abdominis acts synergically with the glutei; the glutei reduce the pelvic inclination and the abdominals reduce the lumbar curve. This is very noticeable in patients suffering from anterior poliomyelitis with residual paralysis of the abdominal muscles. The lordosis may then become extreme, particularly when sitting, and cause much discomfort.

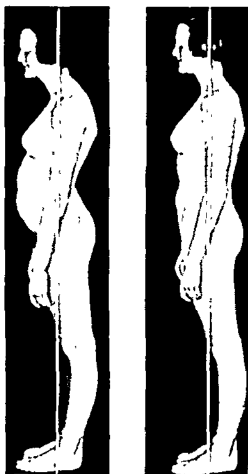


Fig 8
Left Lordosis
Right The posture is immediately corrected by reducing the pelvic inclination

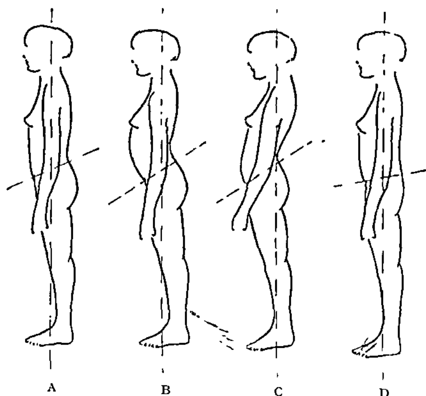


Fig 9
A Normal B Lordosis C Sway back D. Flat back

Two components contribute to make up the majority of defects: (*a*) an increase or a decrease in the pelvic inclination, the former being the commoner, and (*b*) thoracolumbar kyphosis. These two variables combine to produce four distinct types which include the majority of defects.

Increased pelvic inclination plus *mobile spine* .... *lumbar lordosis*
Increased pelvic inclination plus *thoracolumbar kyphosis* ... *sway back*
Decreased pelvic inclination plus *mobile spine* .... *flat back*
Decreased pelvic inclination plus *thoracolumbar kyphosis* ... *round back*

Lumbar Lordosis. The mechanism of the production of lordosis can be visualized as follows: first the pelvis tilts forwards and with it the whole

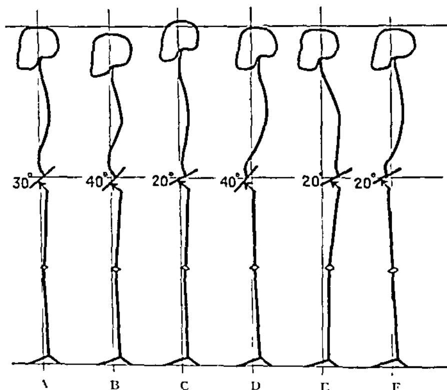


FIG. 7
A Normal B Lordosis C Flat back D Sway back E Round back, type I
F Round back, type II

trunk, then the centre of gravity is restored to above the feet by bending backwards in the lumbar region thus increasing the concavity (Fig. 7b). There is often a general slump of the anti-gravity muscles permitting some increase in the thoracic curve, sagging at the shoulder girdles, internal rotation of the legs and valgus feet. The mastoid line bears much the same relation to the large joints in the corrected and uncorrected positions. Thoracic kyphosis is not marked and the appearance is very different from adolescent kyphosis with compensatory lumbar lordosis (Fig. 61, p. 97).

The typical clinical picture is of a child with a tilted pelvis, increased lumbar curve, drooping shoulders, head poked forwards, internally rotated legs and valgus feet. The dominating feature is, however, the pelvis and the whole posture is immediately corrected by reducing the pelvic inclination (Fig. 8).



Fig. 11. Round back type I. In both types the posture is improved by increasing the pelvic inclination.

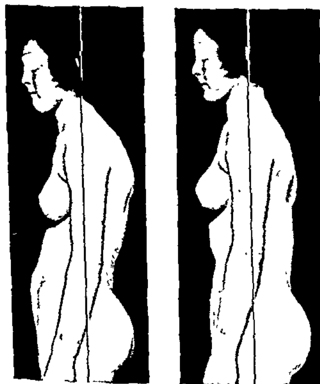


Fig. 12. Round back type II.

Sway Back. Forward tilting of the pelvis is associated with thoracolumbar kyphosis. *The kyphosis is sometimes quite small, really no* more than a little flattening of the upper part of the lumbar concavity; even this amount, however, is sufficient to prevent the spine compensating for the tilted pelvis by a general increase in the lumbar curve, as occurs in the previous type. *Instead the spine is bent backwards rather sharply at* the lumbosacral angle and the centre of gravity is stabilized by inclining the legs slightly forwards at the ankles so that the pelvis projects forwards making the pubis the most prominent part (Figs. 7D and 10). The mastoid *line passes well behind the great trochanters, and a plumb line from the* most prominent part of the dorsal convexity falls behind the sacrum.

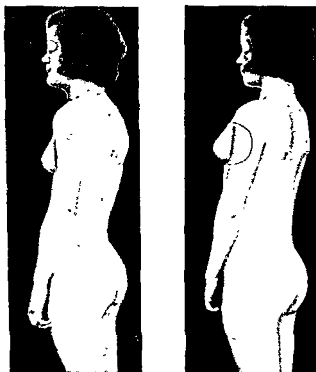


FIG. 10 Sway back Reducing the pelvic inclination greatly improves the posture although it makes the dorsolumbar kyphosis more apparent

There is also a general slump of the anti-gravity muscles with the associated drooping shoulders, internally rotated legs and valgus feet.

Round Back. This is a rather less clearly defined group in which a decreased pelvic inclination is associated with thoracolumbar kyphosis. The centre of gravity may be stabilized in two ways. In type 1, which gives the name to the group, the trunk is bent forwards in the lower lumbar region obliterating what is left of the lumbar curve. The legs are inclined slightly backwards at the ankles and the great trochanters are behind the mastoid line (*Figs. 7E and 11*). The mechanism in type 2 is very similar to that in sway back. The legs are inclined forwards and the trunk backwards causing a low lumbar angulation, and the great trochanters are in front of the mastoid line (Figs. 7F and 12).

usually includes all the lumbar and thoracic vertebræ, the apex being in the mid- or lower dorsal region (total scoliosis). Rotation of the vertebræ, if any, is slight, and there is no deformity of the ribs.

The diagnosis depends on the absence of fixed deformity and the absence of radiological evidence of alteration in the shape of the vertebræ. The curve is abolished by flexion of the spine, by standing on one leg or by any similar movement that involves synergic contraction of the erector spinæ. It frequently, but not always, disappears when sitting, and when standing many patients can correct it by voluntary muscular effort. It is so important to distinguish postural curvature from early structural scoliosis that an X-ray should always be taken.

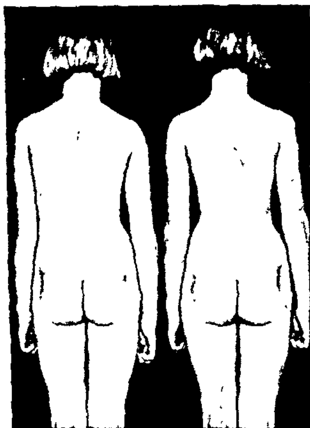


FIG 13 Postural lateral curvature corrected by voluntary effort Note the increase in height

The prognosis is excellent. It can be said with some certainty that a stural curve will correct itself, and it seldom persists into adult life. lults with postural curvature are more likely to have acquired it freshly, d since then it is often the result of bodily or mental fatigue, attention ould be directed to this.

The treatment of postural curvature is identical with that of other stural defects (p. 39) but correction is more simple and therefore remedial eatment is less important. The defect is often an indication that all is t well with the child's general health or emotional adjustment, but when ese are satisfactory postural correction is easily achieved.

Flat Back. This is just as much a deformity as an unduly curved back, but less common. The pelvic inclination is reduced, and the lumbar spine is flattened in compensation, by a mechanism which is the reverse of that in lumbar lordosis (Fig. 7C and 9). Children with a reduced lumbar curve are often described as having a "lovely straight back" but the posture is not good. Such backs become stiff later in life causing intractible backache and therefore the posture should be corrected during childhood.

Round Shoulders. This defect seldom exists alone as a clinical entity but constitutes part of a general postural defect. It occurs when the cervical and thoracic muscles suspending the scapulæ allow them to fall downwards and forwards under the influence of gravity in a direction determined by the contour of the upper ribs. The effect is exaggerated by a slight increase in the thoracic curve which is usually present, and by poking the head and neck forwards.

Failure to recognize during treatment that round shoulders are only part of a more general defect leads to the assumption of that grotesque attitude, the old-fashioned "military position," which results from throwing out the chest, forcing back the shoulders and drawing in the chin without correcting the pelvic inclination.

POSTURAL LATERAL CURVATURE

Postural lateral curvature is an entirely different condition from structural scoliosis and is a disorder in function of similar ætiology to other postural deformities. It is not associated with changes in the shape of the vertebræ and it can be fully corrected by voluntary effort. The older surgeons, who believed that scoliosis was often caused by occupational habits, concluded that postural lateral curvature was frequently transformed into a structural scoliosis. It is, however, doubtful if this ever occurs, and in the rare instance when it appears to, it is probable that a structural scoliosis has been seen at a very early stage before there are any radiological changes. The very word scoliosis has a serious significance in the minds of both laymen and doctors, and since postural lateral curvature has a different ætiology and a different prognosis, it is better not to classify it with scoliosis but to include it with postural defects where it properly belongs.

Lateral curvature which is completely or partly correctible also occurs when there is lateral tilting of the pelvis caused by disparity in the length of the lower limbs. Difference in length up to a third of an inch is of no significance and indeed it is not infrequently present without the patient being aware of it; the curvature produced is so slight as to be noticeable only on careful examination. Changes in the shape of the vertebræ sometimes occur so it is discussed with structural scoliosis on page 108.

Postural curvature occurs chiefly in adolescents, and in girls more often than boys (Fig. 13). There is a smooth curve without sharp angulation, and it is convex to the left more frequently than to the right. It

usually includes all the lumbar and thoracic vertebræ, the apex being in the mid- or lower dorsal region (total scoliosis). Rotation of the vertebræ, if any, is slight, and there is no deformity of the ribs.

The diagnosis depends on the absence of fixed deformity and the absence of radiological evidence of alteration in the shape of the vertebræ. The curve is abolished by flexion of the spine, by standing on one leg or by any similar movement that involves synergic contraction of the erector spinæ. It frequently, but not always, disappears when sitting, and when standing many patients can correct it by voluntary muscular effort. It is so important to distinguish postural curvature from early structural scoliosis that an X-ray should always be taken.

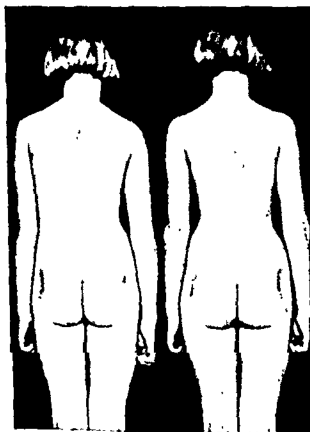


FIG. 13 Postural lateral curvature corrected by voluntary effort Note the increase in height

The prognosis is excellent. It can be said with some certainty that a postural curve will correct itself, and it seldom persists into adult life. Adults with postural curvature are more likely to have acquired it freshly, and since then it is often the result of bodily or mental fatigue, attention should be directed to this.

The treatment of postural curvature is identical with that of other postural defects (p. 39) but correction is more simple and therefore remedial treatment is less important. The defect is often an indication that all is not well with the child's general health or emotional adjustment, but when these are satisfactory postural correction is easily achieved.

THE FEET

The Longitudinal Arches

The feet have the dual purpose of supporting the body in the static rôle of standing and propelling it forwards during locomotion. The human feet are constructed in a manner peculiar to man and are well suited to meet these demands. They are divided functionally into two parts, an inner part concerned principally with weight-bearing, and an outer concerned with stability and balance.

The way in which the feet carry out their static and supporting rôle is very clearly explained by Wood-Jones. He points out that the two feet together rather than a single foot is the unit of support. "We do not carry our body weight," he says, "on legs and feet that may justly be regarded as two columns of support. That is the way in which an elephant's weight is transmitted through columnar legs and feet. The human stance is, however, to be likened to the business of carrying the weight on two half columns rather than on two whole ones."* The prints of the two feet placed close together are approximately circular in shape and they enclose a nearly circular area without contact with the ground; the slender-built outer part of the foot lies flat and gives stability and balance (Fig. 14). There is no real arch to the lateral side of the foot but the supporting bones, the calcaneus, the cuboid and the fourth and fifth metatarsals, are slightly bowed to give them spring. There is a fair range of up and down movement at the fourth and fifth tarso-metatarsal joints which materially assists in balancing.



FIG 14 The prints of the two feet show the area of support (Redrawn from Wood-Jones)

The inner side of the foot is of massive build suited to its heavy work of weight-bearing and propulsion. It has a very definite arched structure which is visible both in the outward appearance and in the internal arrangement of the trabeculæ of the bones. The arch is formed by the calcaneus, talus, navicular, the cuneiforms and the inner three metatarsals. The classical attempts to liken this arch to an architectural structure stimulated a lively controversy which has provided light entertainment over a period of years. Professor Wood-Jones has, perhaps, disposed of the simile finally in the book from which quotation has already been made. It is true that

* The Foot. Baillère, Tindall & Cox. London. 1944. page 244

the arrangement of the bones does resemble a low arch but the surfaces of the joints are curved, unlike a masonry arch whose components have flat surfaces, and the foot collapses when the supporting muscles are removed. The shape of the joints is cunningly contrived to fulfil three purposes: it enables the bones to be held in the desired position with a minimum of muscular effort, it gives resilience to absorb the enormous stresses to which the foot is subjected, and it makes provision for fatigue by permitting the foot to rotate in such a way that the arch disappears and the inner border rests on the ground.

There is no normal height for the arch, and much as a high-arched foot may be admired by some, a low arch can give equally satisfactory use to its possessor. The shape of the foot is subject to as much individual

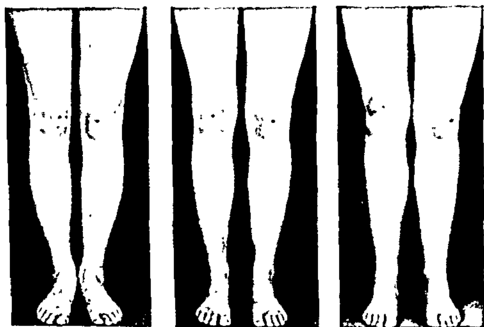


Fig. 15 *Centre*—Habitual posture with the patellæ facing straight forwards
Left—Internal rotation of the legs lowers the arch.
Right—External rotation of the legs raises the arch

variation as any other part of the body. It may be long, short, fat, thin, broad or narrow in almost every combination, and just as there is an appropriate posture for every type of back which reduces stress to a minimum, so for every type of foot there is an appropriate posture. The foot is a supple structure with a fair range of movements and the height of the arch is not constant even in one individual; it depends on the posture at the moment, and it can be varied at will provided the foot has retained its suppleness (Fig. 15). The posture, just as elsewhere in the body, is determined by the position of the joints which in turn depends on the muscles controlling them. In some positions the arch appears lower than in others, and indeed the outward signs of the arch can almost be abolished in a fully mobile foot.

The degree of mobility varies greatly. Members of those branches of the human race who habitually go unshod or wear only sandals often retain

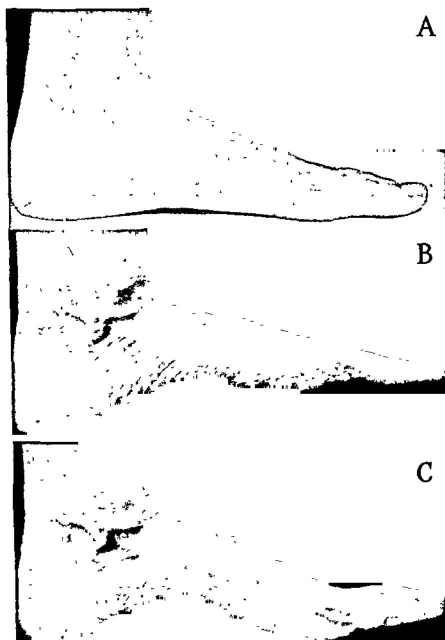


FIG 17

A. Pes valgus
B The foot is inverted and adducted at the subtaloid and talo-navicular joints by the tibialis anterior and posterior muscles
C The tibialis anterior is relaxed and then the first metatarsal is depressed by the peroneus longus thus restoring the arch

full mobility throughout life. Amongst those who wear boots or shoes there is tendency to lose some movement even during childhood, and in adults restriction is the rule rather than the exception. Such people have not sufficient mobility to enable them to rest the inner borders of their feet on the ground. Since extreme mobility is usual in the new born of all races, there is a prima facie case to attribute the acquired stiffness to the environmental influences of western civilization.

The Transverse Arch. This is discussed in connection with pain in the forefoot on page 257.

Movements of the Foot

The joints between the principle bones of the foot are curved in one or more planes and this makes their movements rather complicated. The movements can be divided into three groups: an extensive swivelling movement at the subtaloid complex of joints, a moderate range of up and down movement of the inner border of the foot, chiefly the first metatarsal, and a limited amount of up and down movement of the outer border of the foot.

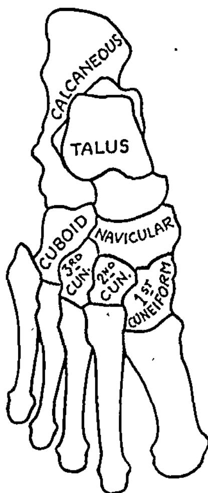


FIG 16 The foot (after Gray's Anatomy) The bones in the shaded area are closely interlocked and move almost as one piece around the axis of the talus at the subtaloid and talonavicular joints

The joints of the entire tarsus, excepting only those in connection with the talus, are spanned by interosseus ligaments, by the tendinous insertions of the tibialis posterior, and by the long and short plantar ligaments, in such a way that only a very limited range of movements is possible (Fig. 16). However, there is very free movement between the talus and the other bones of the foot to which it is joined only by the talo-calcanean interosseus ligament; this ligament is situated near the axis of rotation of the talus on the calcaneus and permits a considerable range of rotary movement.

The whole foot works together as a unit and moves almost as a solid piece around the talus at the talo-calcanean and talo-navicular joints. These two joints, although they are anatomically distinct, function as one, and they are so shaped that movement in one direction inverts and adducts the foot, and in the other direction everts and abducts it. The former movement raises the inner border of the foot from the ground (Fig. 17b); if the first metatarsal is then lowered without allowing the rest of the foot to evert, the height of the arch is increased (Fig. 17c).

Similarly the arch is "lowered" into a valgus or "flat-footed" position by everting the foot and raising the first metatarsal.

Identical changes in the posture of the feet are produced by keeping the feet still and rotating the legs at the hips because the talus is fixed in the mortice of the ankle and moves with the leg. When the feet are kept still and the legs are rotated to make the patellæ face inwards, the arches are lowered; when the patellæ face outwards, the arches are raised (Fig. 18).

The mid-tarsal joints (i.e. the talo-navicular and calcaneo-cuboid joints) are sometimes stated to be the joints at which inversion and eversion chiefly takes place, but this is not so. These two joints do not form a functional unit and comparatively little movement of the forefoot is possible when subtaloid movement is prevented.

Muscular Control

The tibialis posterior is inserted into the navicular and has expansions to every other bone in the foot except the talus and the first and fifth metatarsals. When it contracts it approximates the navicular to the internal malleolus, and the whole foot moves with it swivelling round the talus into a position of inversion and adduction (Fig. 17b).

The peroneus longus is inserted into the under-surface of the base of the first metatarsal and the first cuneiform. It is primarily an evertor and abductor of the foot, but when evertion is prevented by the synergic action of the invertors, its continued pull is applied to the bones into which it is inserted and the first metatarsal is depressed (Fig. 17c). The balance of the body, as when standing on one foot, is maintained largely by small variations in tension of the invertors and evertors.

The tibialis anterior is inserted into the base of the first metatarsal and the first cuneiform and its action is rather complicated. Its chief function is to dorsiflex the ankle, but it assists with inversion of the foot and it also elevates the first metatarsal. When walking, it is the first muscle to contract when the foot is about to leave the ground thus initiating the small movement of dorsiflexion at the ankle that is necessary to enable the toes to clear the ground as the leg swings forward.

The effect of gravity is such that the foot tends to rotate into the everted, abducted position and reduce the visible longitudinal arch. The invertors are comparatively small muscles and they could not alone maintain the inverted position of the foot against the stress of the whole body weight. It has already been pointed out that the shape of the joints is so arranged that external rotation of the leg has the effect of inverting the foot provided the foot is prevented from moving with the leg by pressure against the ground. External rotation of the leg is carried out by the glutei and therefore the powerful gluteal muscles must be included as invertors and adductors of the foot. The action of the talus is not unlike that by which a cam expands the shoes in the brake-drum of a motor-car and it enables the glutei to work at a great mechanical advantage.

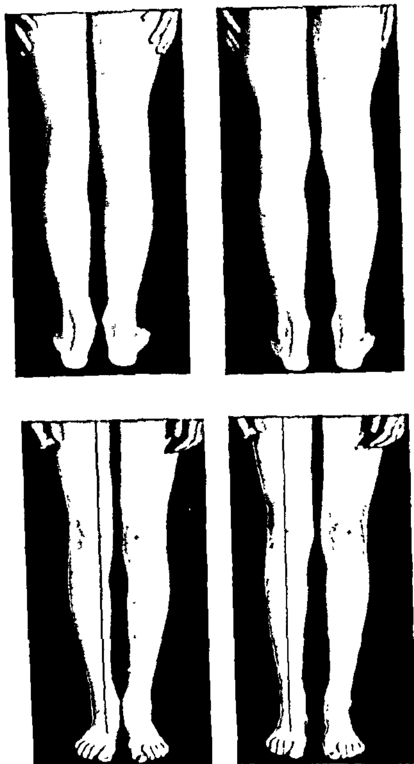


Fig 18 Postural pes valgus of moderate severity showing correction obtained by external rotation of the legs at the hips

The important movements of the foot are carried out as follows :—

inversion and adduction—tibialis posterior, flexor digitorum longus, flexor hallicus longus and, when the foot is pressed on the ground, the glutei.

eversion and abduction—peroneus longus and peroneus brevis.

elevation of first metatarsal—tibialis anterior.

depression of first metatarsal—peroneus longus.

Normal Gait

Human locomotion is a phenomenon of extraordinary complexity and only by the application of modern engineering methods has it been possible to analyse it in sufficient detail to permit real understanding of pathological gait.* Locomotion has the simple object of transferring the body from one place to another. It can best be studied by examining the path followed by the centre of gravity. This path is determined by a number of factors of which the most important are (1) pelvic rotation at the hip alternately to the right and the left, (2) downward pelvic tilt at the hip, (3) flexion at the knee, (4) extension at the ankle and (5) lateral displacement of the body to the right and the left as the supporting foot changes. The displacements produced by these factors summate to give a smooth curve with a deflection of small amplitude in both vertical and horizontal planes. It corresponds closely with theoretical calculations as to the most economical method of progression. Pathological gait induced by restriction of movement at one joint is compensated at other joints in such a way that the path is changed the smallest possible amount thus conserving the expenditure of energy.

The whole body weight is carried at each step by one foot, and for a moment by the ball of the foot only. When walking ordinarily, the heel of the leading foot makes contact with the ground just after the centre of gravity has reached its lowest point. The foot, at that instant, is dorsiflexed, but the forefoot is quickly lowered by the extensors of the ankle. Immediately afterwards the entire body weight is transferred to the foot; it remains on this foot whilst the other leg swings forwards and then, just before the heel of the latter touches the ground, the calf muscles contract to dorsiflex the ankle and transfer the weight to the metatarsal heads.

The foot strikes the ground first slightly to the outer side of the heel, then at the outer side of the forefoot, and finally, the inner side of the forefoot. During the greater part of the time that the body weight is on the foot, the whole foot is in contact with the ground. The ankle is so placed in relation to the foot that about two thirds of the weight is carried by the heel and one third at the level of the metatarso-phalangeal joints. The whole weight is on the forefoot for a comparatively short time, and for a moment, during the final propulsive movement, it is on the ball of the big toe alone. With a normal gait, the shoes show most wear a little to the outer side of the heel and at the inner side of the tread.

*Saunders, Inman and Eberhart *Journal of Bone and Joint Surgery*, 1953, 35A, 543.

PES VALGUS

(*Synonym*) Flat foot.

The expression "flat foot" is in popular use to describe a number of disorders ranging from simple postural defects to peroneo-extensor spasm and it is expressly avoided here because of these misleading associations. The term "pes valgus," although not strictly accurate, is used instead in the hope that it will lead to clearer thinking.

A valgus posture of the feet may be adopted for many reasons; it is in fact no more than a symptom which is common to a variety of disorders, just as stomach-ache is a symptom and not a disease in itself. The commonest type of pes valgus is a postural defect of similar ætiology to other postural defects and usually occurring in association with them. There are, however, several minor structural abnormalities which cause the feet to assume a valgus position and it is important to recognize them when they occur because postural correction is then impossible.

Valgus feet are essentially painless although they are subject to the same causes of pain as feet of any other shape. Not only is it useless to tell a patient that his feet hurt just because they are flat, but it is positively harmful as it prevents the real cause of the pain being sought.

The following varieties of valgus feet may occur separately or in combination :—

1. *Infantile type.*
2. *Part of a general postural defect.*
3. *Associated with genu valgum* (p. 32).
4. *Compensatory to*
   a. Internal torsion of the tibiæ.
   b. Obliquity of ankle joints.
   c. Short tendo-Achillis.
5. *Muscular weakness.*
6. *Paralysis.*
7. *Peroneo-extensor spasm* (spasmodic flat foot) (p. 252).

Infantile Type. Many infants, particularly asthenic children with long, thin feet, are noticed to have valgus feet as soon as they begin to stand. The reason is probably to be found in the position of the fœtus in utero which may be such as to cause the feet to develop in a valgus position. The condition may be regarded as a very mild talipes calcaneo-valgus with the valgus element predominating (p. 312). The feet have full mobility and there is not usually an associated postural defect.

TREATMENT. A few children rapidly acquire a better posture, a large number show little change until seven to ten years of age when they improve spontaneously, and in the remainder the defect persists into adult life. Active treatment is of little value during the first few years of life but the child should be kept under observation to make certain that the feet remain supple. The heels of the shoes may be wedged if desired. At about six years of age the child is old enough to co-operate in remedial treatment as described for general postural defects.

General Postural Defect. Pes valgus is nearly always due to faulty posture and has the same causes as other postural defects, but this will only be appreciated if every patient complaining of "flat feet" is examined completely undressed. The onset is usually during childhood or early adolescence and the posture of the feet is often the first defect to be noticed by the parents. There is a general slump of the extensor muscles which permits the pelvis to rotate forwards increasing its inclination, and the legs to rotate inwards thus twisting the feet into a valgus position (Fig. 18). The nature of the defect can be demonstrated at once by getting the patient to use the glutei to tilt back the pelvis and externally rotate the legs whilst keeping the feet still.

TREATMENT. Little can be done to affect the posture of a child until he is of an age to co-operate willingly. Parents, however, are so concerned that their children should be physically perfect that they often demand treatment, and the doctor is naturally anxious to do his best. As a consequence many methods of treatment have been devised, and although a number have become traditional, the extent to which they really influence development is doubtful.

Exercises. It follows from the account already given of the mechanics of postural pes valgus that the defect can only be corrected if the rotation of the legs at the hips is also corrected. The treatment is, therefore, as for general postural defects; this is not merely a matter of doing exercises but a process which involves the conditioning of new postural reflexes. The ordinary foot exercises given at schools throughout the world to many thousands of young children have little more effect than to keep the feet supple—those whose posture is going to improve will do so whether they attend "foot classes" or not. Remedial methods are discussed in detail on page 39.

Arch supports are no longer prescribed for this condition, even to comfort the parents. They are a relic of the old idea that the arch of the foot is a structure capable of being propped up, the rotational element being ignored. If supports have any effect it is because they are uncomfortable enough to make the child assume a posture that rids him of their pressure. They have the disadvantage of preventing the natural movements of the feet which therefore become stiff; a stiff foot is often painful and this may make supports a permanent need.

Shoes. It is not possible to correct valgus feet by wearing shoes of any special design; nor can ankles which "roll in," for they are but part of the same postural defect, be held up by wearing boots. The shape of the shoes should correspond with the shape of the feet. Most children's shoes are now made a reasonable shape (although the same cannot be said of the quality of the materials), and it should be sufficient just to buy a pair that fit comfortably. Unfortunately the variety of fittings available in Great Britain is much too small, even at specialist shops, and a proper fit is often unobtainable.

The axis of the shoes should correspond with that of the feet. Some shoes, they are often called "surgical" or "orthopædic" shoes, are designed

with the forefoot inclined inwards relative to the heel and the axis passes to the outer side of the second toe as shown in Fig. 19C. The axis of the "normal" foot passes through the second toe (Fig. 19A), whilst in a valgus

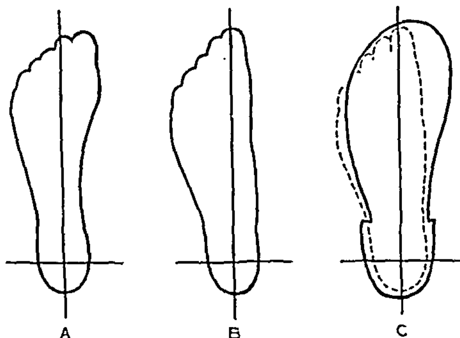


Fig 19

A Normal foot the axis passes through the second toe
B Valgus foot - the axis passes to the inner side of the second toe
C The axis of the shoe is such that it does not fit either of these feet

foot it usually falls to the inner side of the second toe (Fig. 19B). Shoes of this design, although comfortable for feet of corresponding shape, must cause pressure on the little toes and fifth metatarsal heads of feet with a "normal" or a valgus posture.

Wedges. A valgus wedge (i.e. one which corrects a valgus deformity and has the base facing inwards) fixed to the heel of the shoe rotates the heel inwards at the subtaloid joint and gives some correction. If the sole is wedged also, it prevents the inner border of the foot being depressed thus leaving the foot in the same relative position but standing on a sloping surface; wedges should, therefore, be fixed to the heel only. The base of the wedge may be ⅛ inch thick in infants and $\frac{3}{16}$ inch in older children and adults; thicker wedges are not readily tolerated. They can be fixed as patches outside low heels, but when the heels are higher they should be placed between the welt and the heel to keep the latter vertical (Fig. 20). Although wedged heels are theoretically useful, it is doubtful if they have much effect in practice because of rapid wear and because they can only help when standing on a hard surface. They are troublesome to keep

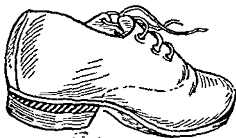


Fig 20 Valgus wedge to heel only

in repair, and there is a tendency for parents to stop their children running about in bare feet, a much more useful habit, "because of the wedges." On the whole, wedges are more trouble than they are worth. They serve mainly to let the surgeon think he is giving active treatment without going to the trouble of organizing proper remedial methods, and to enable parents to think they are doing everything they can to help their child.

Extended heels are a device which come into the same category as wedges. They are unnecessary when the sole of the shoe is made of leather of proper strength and thickness. If the soles are of poor material, they are pushed up to make an uncomfortable lump.

Torsion of the Tibia. The malleoli in a normal person are not set in the coronal plane but the external malleolus is posterior to the internal. The angle between the plane of the malleoli and the coronal plane can be estimated roughly when the patient is seated and one leg is held with the knee straight and the patella facing exactly upwards as in Fig. 22. The angle varies considerably in different individuals; the average is about 20° but between 10° and 30° is within the normal range. The torsion is not always the same in the two legs and when different it is usually less on the left side than on the right.

In the newborn the average angle is much smaller than in adults but there is a wide variation between individuals and, very frequently, a considerable difference between the two legs. At birth the malleoli commonly lie more or less in the coronal plane; the external malleolus may, however, be advanced in front of it, and sometimes the angle is the same as in the adult. As a rule the angle increases rapidly during the first few months of life, and thereafter more slowly until the adult plane is reached at the age of about four years. There is seldom any spontaneous change after six years of age. The alteration in the angle is thought by some to be due to a true change in the torsion of the tibia during early growth, perhaps a phenomenon associated with adaption to the upright posture of man.

An abnormality in tibial torsion is quite a common cause of postural defects and it should be sought as a routine. The usual abnormality is a decrease in the amount of external torsion; the external malleoli are then advanced in relation to the internal and lie near the coronal plane. The feet therefore point inwards (Fig. 21) and since this pigeon-toed position is awkward, the patient unconsciously everts the feet into a valgus position to make them parallel. Sometimes there is an associated general postural defect in which the hips are internally rotated; this causes the valgus posture of the feet to be more extreme and may mask the torsional deformity unless it is looked for. External torsional deformities have the opposite effect; they are often associated, as either cause or effect, with high-arched feet and pes cavus (page 266).

Treatment. Estimation of the plane of the malleoli should be a routine examination at infant welfare clinics. There need be no concern during the first year, but if the external malleolus is not behind the coronal plane by two years of age, and if the records show that the angle has not

changed since birth, treatment is desirable. Treatment is also indicated if there is appreciably less than 5° of external torsion at the age of six.

Correction can usually be obtained with a modified Denis Browne's splint (Fig. 237, p. 311). The splint is made without a leg piece and an open-toed lace shoe is rivetted to the sole plate; the foot of the affected side, or of both sides is necessary, is turned out to a right angle. The splint is worn at night only and the effect is to impose an external torsional strain on the bones during about half of each 24 hours of growth. It is seldom necessary to use the splint for longer than three months. Rotation osteotomy of the tibia is indicated only on very rare occasions.





Above FIG 22 Estimating the torsion of the tibia, which in this child is normal

Left FIG 21 Internal torsion deformity of the tibiæ

It is undesirable to attempt to correct valgus feet secondary to internal torsional deformity of the tibiæ by teaching the child to rotate the legs externally at the hips, as is advised for postural defects. The resulting position is difficult to maintain and it is uncomfortable because the feet cross when the knees are bent during walking or running.

Congenital talipes equinovarus is usually accompanied by an internal torsional deformity of the tibia but it corrects spontaneously during treatment of the foot (p. 308). In older children with uncorrected deformity of the feet, rotation osteotomy is often desirable. It may also be necessary, but with rotation in the opposite direction, after operative correction of pes cavus.

Obliquity of the Tibial epiphyses. The lower articular surfaces of the tibiæ sometimes fail to develop evenly and slope a little inwards instead of being parallel with the ground. The soles of the feet then face slightly towards each other, but when bearing weight they are restored to the horizontal by evertion into the valgus position. The deformity may be due to mild rickets but as a rule no cause can be found.

The condition can be detected clinically by the position of the feet when they are passively held in their natural position in relation to the tibiæ. It is confirmed by X-rays taken of both legs whilst the patellæ are facing exactly forwards (Fig. 24). The general impression given by the defect is of incurving of the tibiæ (p. 35), but whilst it is true that severe incurving of the tibiæ causes obliquity of the ankles, radiological examina-

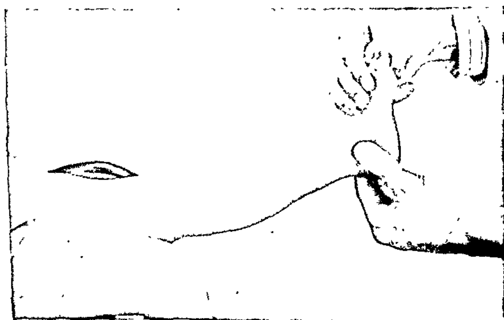


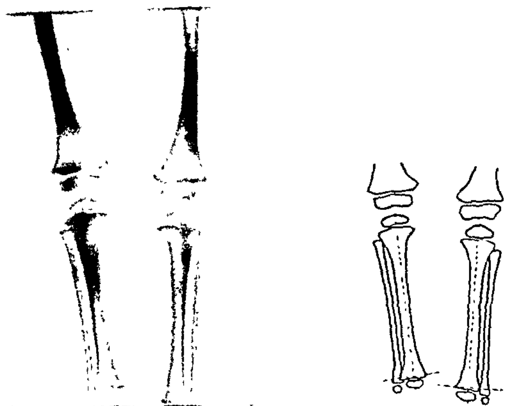
Fig 23 Estimating the range of *dorsiflexion at the ankle joint.*

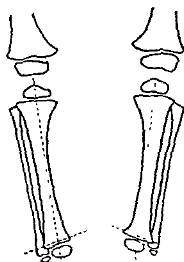
tion shows that the reverse does not hold and obliquity is often present without incurving.

Treatment. There is often spontaneous improvement during growth and no treatment is possible except on the rare occasion when the deformity is severe enough to warrant osteotomy of the tibiæ.

Short Tendo-Achillis. This term is used to describe a condition in which dorsiflexion at the ankle is restricted, although it cannot be said whether it is the tendon or the muscle that is short, or both. A minor degree of limitation of dorsiflexion is very common in adults, more so in women than in men, and it is a frequent cause of valgus feet. The defect appears to be due to failure of the calf muscles to adjust in length during growth. It may sometimes be attributable to wearing shoes with high heels too early in life.

Dorsiflexion at the ankle is measured with the patient sitting (Fig. 23). The leg is raised to straighten the knee and supported with one hand under





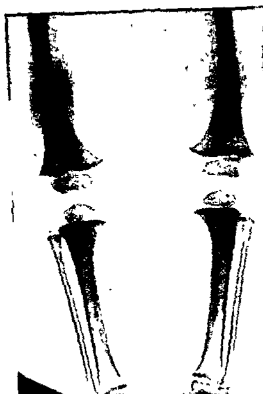


Fig 24 *Above*—X-ray of a normal child aged 20 months
Below—Obliquity of the lower tibial epiphyses causing pes valgus.

the heel; the toes are held with the other hand and the foot is placed in the position it should assume when standing, neither inverted nor everted. It is then dorsiflexed at the ankle with a moderate amount of pressure, care being taken to ensure that it is not forced into valgus as then it appears to dorsiflex more.

The foot in the newborn will dorsiflex almost until the toes touch the shin, but the range decreases gradually during childhood. The adult foot normally dorsiflexes to about 10° above a right angle. If dorsiflexion to a right angle is impossible, the heel is unable to touch the ground when standing bare-footed unless the forefoot is raised by everting it into the valgus position. When wearing shoes the heels compensate for limitation of dorsiflexion and the feet are not valgus. Minor degrees of limitation do not as a rule cause symptoms although there may be pain after playing games in low-heeled shoes.

TREATMENT. The ordinary postural methods are useless. Young people may be improved by wearing heel-less shoes, by ballet dancing or by physical exercises. Passive stretching may be tried: the feet are placed side by side and the knees bent without letting the heels rise from the ground; if the legs are pressed together at the same time, it is harder for the feet to be forced into valgus. Adults do not respond to conservative treatment and usually should be advised to accept the defect and wear heels of a suitable height. Lengthening the tendo-Achillis by operation is very occasionally necessary in children.

Major degrees of shortening of the calf muscles occurring in connection with congenital talipes, and in disorders such as anterior poliomyelitis and spastic paralysis, are discussed in other chapters.

Muscular Weakness. Habitual pes valgus is not ordinarily caused by muscular weakness. Temporary valgus may, however, occur as the result of fatigue, for example, in a young adult first starting work which involves much standing, such as shop assistant. The whole extensor mechanism then tires, the body sags and the feet rotate into valgus. When the feet are supple this causes little more trouble than tiredness and aching, but if the feet are stiff, it may produce chronic foot strain (p. 250).

Paralysis. When the invertor muscles are paralysed, particularly the tibialis posterior, the foot assumes a position of extreme valgus. The commonest cause is anterior poliomyelitis. Residual weakness or paralysis of only one group of muscles is not uncommon after this infection and the possibility should be remembered even when the acute attack passed unnoticed (p. 503).

Peroneo-extensor Spasm. (Spasmodic flat foot.) This is not a postural defect but an entirely different condition in which the valgus position of the foot is merely incidental. It is readily recognized by the obvious spasm of the peroneal muscles and the long extensors of the toes which prevents passive correction of the deformity. It should not be overlooked because immediate treatment is necessary. Only too often the presence of spasm is ignored thereby condemning the child to a life-long and serious disability. The condition is discussed on page 252.

GENU VALGUM

(*Synonym*) Knock-Knee

Genu valgum is so common during infancy that it can hardly be regarded as abnormal. Indeed, it is probable, although there are no accurate figures, that the majority of children are knock-kneed at some stage during their development. Nearly all correct spontaneously and the number of adults with this deformity is very small. The concern of parents, and also of many doctors, is a relic of the days when rickets was common and a gross deformity often persisted. It is, however, wise



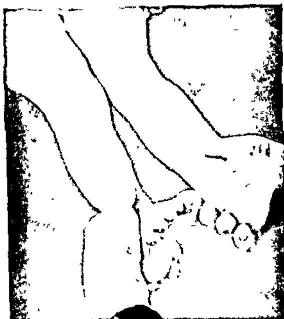


FIG 25 Measuring the amount of knock-knee The knees must be fully extended and the patellæ face exactly upwards

for children with an appreciable amount of deformity to be kept under medical observation because a few fail to recover and, moreover, it may be the first sign of some general disease.

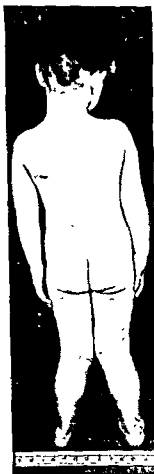
The types of genu valgum are :—

Idiopathic.
General disease—rickets,
renal osteodystrophy,
dyschondroplasia, etc.

The amount of knock-knee is measured by the distance between the internal malleoli as shown in Fig. 25. Care must be taken to make sure that the knees are straight and the patellæ face exactly upwards ; the legs are brought together with moderate pressure which is applied firmly enough to compress excessive subcutaneous fat. The amount of pressure used by one surgeon can always be about the same and his estimations of knock-knee are fairly constant, but different surgeons may obtain different measurements for the same patient. Excessive subcutaneous fat exaggerates the clinical appearance of knock-knee.

"Idiopathic"

Knock-knee in young children, at any rate in Great Britain where florid rickets is now uncommon, is almost invariably of the "idiopathic" type (Fig. 26). It is caused by growth at the outer side of the epiphysial disc at the lower end of the femur proceeding rather more slowly than at the inner side. The line of the knee joint therefore slopes slightly upwards and outwards, instead of being horizontal. In a large majority growth at the outer side eventually catches up with the inner and the defect rights itself spontaneously. The reason for this irregularity in growth is quite unknown.


Fig 26 "Idiopathic" knock-knee There was no evidence of rickets

Laxity of the internal lateral ligaments is often present in knock-knee because of the additional strain that falls on the inner side of the joints. This allows the joints to "open up" whilst standing relaxed thus increasing the amount of deformity, but the laxity is controlled by muscular action when walking or running.

Pes valgus is frequently associated with the more severe degrees of knock-knee, especially in heavy children. There is often a poor general posture with an internal rotational defect of the legs, and pes valgus occurs partly in compensation for this (p. 24), and partly because of increased pressure on the inner borders of the feet. The posture of the feet usually recovers spontaneously as the knees become straight, but remedial treatment is required if the internal rotational defect persists.

Knock-knee often begins to develop a few months after the child starts to walk. A distance of one inch between the malleoli is common by two years of age, and sometimes there is two inches or more. The deformity may then remain stationary for a while before regressing, or it may progress until there is three inches at three to four years of age. The legs are usually straight again by the time the child is six years old.

The prognosis is excellent provided the amount of knock-knee does not exceed about two and a half inches. If it is three inches at three years, the outcome is doubtful although spontaneous correction is still the rule; the child should be examined at three monthly intervals and continued progress is an indication for active treatment. Excessive weight adversely affects the prognosis because the pressure on the internal condyles is increased.

Treatment. "Idiopathic" genu valgum almost always recovers spontaneously and treatment is of doubtful value to most patients. They must, however, be kept under regular observation and progress recorded

in order to pick out the few who fail to improve. The children perhaps should avoid standing as much as possible, and they should not be made to stand or walk with the feet together, indeed it is an advantage to walk with them apart. Knock-kneed children are clumsy in their movements because their knees get in the way; they have less difficulty if they keep the feet apart, and this also reduces the soreness suffered by fat children whose thighs rub together. Gymnasium and drill teachers should be instructed accordingly.

A few mothers insist on "something being done" but most are satisfied with a detailed explanation and are relieved to find that they have nothing to do—the neighbours often worry more than the mother. The only conservative measure available is to wedge the inner sides of the soles and heels of the shoes. The intention is to relieve the strain on the inner sides of the knees but there is no evidence that recovery is thereby accelerated (p. 25). Massage and remedial exercises are without effect on the deformity.

More active treatment is occasionally necessary but the indications are difficult to define exactly because the percentage of patients likely to recover spontaneously from different amounts of deformity is not known. Treatment is certainly desirable, particularly in fat children, when the deformity has reached three inches by the age of three years and continues to progress during the next year.

The choice of active treatment is between splints and operation. Splints have to be worn for a very long time, often a couple of years. Day splints are cumbersome and interfere with activity to a crippling extent placing the child in grave danger of acquiring cripple's mentality; night splints are open to less objection, but are less effective. On the other hand osteotomy is a safe procedure with a fairly short convalescence which enables all treatment to be finished in about three months. It is most undesirable, if there is any alternative, to inflict a long period of crippledom a child, and operation is greatly to be preferred on the rare occasions hen active treatment is necessary.

SPLINTS. The object of splinting is to apply constant pressure to the g in such a manner as to increase the stress on the internal condyle of the mur and reduce it on the external condyle, and it must be continued for ng enough for growth at the two sides to be equalized. Three points of essure are required—the great trochanter and the external malleolus on e outer side, and the internal epicondyle on the inner side. The corrective rce operates only when the knee is straight because when it is bent the g rotates. Splints consisting of a single bar at the outer side of the leg re therefore useless, and it is necessary to have a second bar behind the g to keep the knee straight.

Splints for night use are generally made from two long pieces of wood f slightly curved cross-section; the shorter piece is bandaged to the back f the leg and then the longer is applied to the outer side. Day splints onsist of a long outside iron with the lower end in a round socket in the eel of the shoe, the upper end is padded to press on the great trochanter,

OR

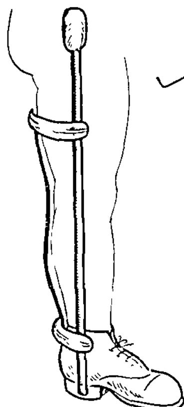


Fig 27 Knock-knee splint
The straps are not shown

and a short posterior iron is attached to the long iron by two quarter hoops; the leg is fixed in the splint by bandages or straps (Fig. 27).

Operation. *Macewen's Osteotomy.* The modification now frequently practised is to introduce an osteotome on the outer side of the femur about 1½ inches above the epiphysial line and divide the bone three-quarters of the way through; the remaining portion is then fractured leaving the periosteum on the inner side intact. A double plaster-of-Paris spica is then applied or else traction as for a fracture of the femur.

Blount's Staples. Growth at an epiphysis can be arrested temporarily by bridging the epiphysial disc with several staples driven into the bone with one leg on each side of the disc. As a rule normal growth is resumed when the staples are removed. If the staples are placed on one side of the bone only, growth is prevented at that side. This should, therefore, be a convenient method of correcting knock-knee. Unfortunately the resumption of normal growth cannot be relied upon with complete confidence. It may be that failure is due to imperfect operative technique, but whatever the cause, permanent arrest of growth at the knee of a young child is a major disaster. Most surgeons reserve the operation for older children whose age is such that growth may be expected to stop naturally at about the time the staples are due for removal.

General Disease

Rickets is the only common disease of bone to cause knock-knee although sometimes it is due to rare affections such as dyschondroplasia. Renal osteodystrophy is an occasional cause and therefore the urine should always be tested for albumen. A generation ago florid rickets was prevalent in Great Britain, but now it is quite rare and therefore knock-knee due to rickets is seldom seen. Knock-knee should only be attributed to rickets when there is definite radiological evidence of the disease (p. 485).

The deformity is due partly to the soft bones bending where the stress is greatest, that is the lower part of the shaft of the femur, and partly to compression of the external condyles of the femur and tibia which are subjected to greater pressure than the internal condyles. A "back knee" deformity (genu recurvatum) is not uncommonly associated.

The deformity in knock-knee due to rickets is often greater than in the "idiopathic" type, and since the tendency to spontaneous recovery is smaller, active treatment is more often necessary. Treatment follows the lines already described but there need be less hesitation in advising operation; three inches of deformity at three years is a definite indication.

GENU VARUM

(*Synonym*) Bow Legs

Tibiæ of normal shape are not quite straight but the inner borders are slightly curved, and this is apparent on both clinical and radiological examination: a straight shin, as may be seen with a malunited fracture, is conspicuous and ugly. An excessive amount of bowing is quite common in children although it is much more often apparent than real.

The types of bow legs are:

Apparent internal rotation of the legs,
obliquity of the tibial epiphyses.

Real—infantile,
rickets,
tibia vara.



Fig 28 Apparent bow legs and pes valgus caused by internal rotation of the legs at the hips and oblique tibial epiphyses

The type can be determined by examining the legs after they have been rotated at the hips to make the patellæ face forwards. Sometimes there is a combination of defects. The boy illustrated in Fig. 28 has also oblique tibial epiphyses which prevent the bow legged appearance from being eliminated entirely. The prominent calves are caused by the presence of genu recurvatum.

The amount of bow legs is measured in a similar way to knock-knee, the internal malleoli being brought together and the distance between the knees measured (Fig. 25).

Internal Rotation of the Legs

Internal rotation at the hip joints, which is a common postural defect, is the usual cause of apparent bow legs in older children and adults. The appearance is produced when a rotational defect is accompanied by some hyperextension of the knees (genu recurvatum). The reason is that the legs, when viewed from the side, are curved slightly backwards, and the plane of the curve is changed by rotation of the legs (Fig. 28). The appearance is immediately corrected by rotating the legs outwards. The treatment is as for other postural defects (p. 39).

Obliquity of the Tibial Epiphyses

Obliquity of the lower epiphyses of the tibiæ has already been mentioned in connection with pes valgus of which it is an occasional cause (p. 28). The radiological appearance suggests that the defect is often due to mild rickets ; it may, however, be present in infants with no evidence of vitamin deficiency and then it appears to be due to a temporary defect in growth similar to that in genu valgum.

The defect can be recognized clinically by the slight inward inclination of the heels and the similar inclination of the forefeet when they are placed in their proper position in relation to the heels. The legs then look as if they were bowed, but there is no gap between the knees when the feet are everted to enable the malleoli to be brought together. X-rays show the nature of the defect and also confirm the absence of bowing of the shafts of the tibiæ (Fig. 24).

The defect usually corrects itself spontaneously during growth. A minor degree sometimes persists but it causes no more inconvenience than slightly valgus feet. Very occasionally the defect is severe enough to require correction by osteotomy of the tibiæ, and on the rare occasions when this is necessary it should be done during early childhood.

Infantile

Most babies are for a time slightly bow legged. The actual site of the defect is not known accurately because of the difficulty in positioning small infants for radiography. It is, however, probable that there is unequal growth on the two sides of the epiphyses, as occurs in knock-knee, but in this case affecting the upper end of the tibia as well as the lower end of the femur. The cause in the first instance may be the intra-uterine posture, and later the wearing of bulky "nappies." No treatment is necessary. The legs straighten themselves spontaneously and, indeed, often become knock-kneed for a while.

Rickets

Florid rickets, although the commonest disease causing bones to soften and bend, is now seldom seen in Great Britain, but when it does occur, the deformity may be very severe (p. 485). The point at which the tibiæ bend depends to some extent on the age of the child. In infants the curve

is chiefly in the lower third of the tibiæ (Fig. 29), but in older children the whole length of the bone may be involved. A backward curve is often superimposed on the inward bowing when the child is young enough to be carried in the mother's arms with the legs hanging over her forearm. The backward element of the deformity, when present, is an important point in the clinical diagnosis because it only occurs when the bow legs is due to softening of the bones. Obliquity of the lower tibial epiphyses is also present in rickets and may be very marked.

Treatment. Spontaneous recovery does not occur except with a trivial amount of bowing and treatment is desirable when the deformity



Fig 29 Incurving of the lower ends of the tibiæ and obliquity of the lower epiphyses caused by florid rickets (cf Fig 24). An X-ray of the same child taken six months earlier is shown in *Fig 362, p 485*

is at all severe, if only for cosmetic reasons. There is, however, no simple method of correction because splints, which have the same drawbacks as in the treatment of knock-knee, should be avoided when possible.

Osteoclasis. This is indicated when there is an appreciable amount of backward bowing, or when there is a gap between the knees of three inches or more at the age of three years. With intermediate degrees of deformity it may be hard to decide when to advise this procedure, but it is a comparatively minor operation and the results are good. The leg is placed with the apex of the convexity of the curve resting on a wedge; it is held close to the wedge to avoid strain on the epiphyses, and fractured. As a rule there is a complete fracture of the fibula and a greenstick fracture of the tibia. The legs are afterwards fixed in plaster-of-Paris in the corrected position for six weeks.

Wedge Osteotomy. With very severe deformities in older children it is preferable to remove a wedge of bone from the convexity of the tibial curve.

Tibia Vara

This condition, first recognised as a clinical entity by W. P. Blount, is an unusual cause of bow legs. There are two types, infantile and adolescent, which differ in both ætiology and prognosis. They are differentiated clinically by the age at onset.

The *infantile type* is the less uncommon. It is caused by a defect in development of both the epiphysis and the metaphysis at the upper end of the tibia, and it may be a form of osteochondritis juvenilis (p. 167). The deformity first appears between one and three years of age and progresses quickly. The bowing is at the upper end of the tibia and is so



Fig 30 Bilateral tibia vara, infantile type (By courtesy of Dr Leo Mayer)

abrupt as to be better described as an angulation. Radiographs (Fig. 30) show irregularity in ossification of the entire metaphysis most marked on the inner side where a beak is formed. The epiphysis also is less well developed on the inner side and in time becomes wedge-shaped.

The treatment is to straighten the legs by osteotomy. This should be done as early as possible because growth is then likely to proceed normally. If operation is delayed until after about six years of age, the deformity is likely to recur.

The adolescent type is characterized by the gradual development of bowing beginning between the ages of eight and thirteen years. The deformity is in the upper part of the tibia, and the whole bone may be somewhat short. The defect is due to an arrest of epiphysial growth commencing at the inner side of the upper tibial epiphysis. The deformity does not always progress and therefore the patient should be kept under observation for some time before advising osteotomy. If there is much shortening arrest of growth of the sound limb may be required.

TREATMENT OF POSTURAL DEFECTS

The physiological basis of the regulation of posture and the reasons why defects arise must be taken into account when planning treatment. It is clear that attention has to be directed not to the muscles, but to the central nervous system which controls them. The objective is not to strengthen muscles, but to change postural habits. Physical exercises cannot by themselves do this; they can only give a facility for making particular movements and they can develop certain muscles. The ordinary school "exercise" classes for bad posture and flat feet are not entirely useless because, if well conducted, they do give the children a certain awareness of posture, and they do teach control of movement and of breathing. It is, however, probable that most of those who improve whilst attending such classes would have done so anyhow. Remedial methods, to be effective, must ensure that the basic defects of each individual are corrected and that the correction is held whilst making the ordinary movements of life.

Before embarking on treatment a complete examination is necessary in order to analyse the mechanics of the defect, to discover the best posture for the individual and to find out if there is sufficient mobility to enable that posture to be attained. When a minor structural abnormality is present, for example, a torsional defect of the tibiæ, the best compensatory posture must be determined. Children in whom psychological factors predominate should not be given physical treatment, which may only add to their troubles, until after the assistance of a psychiatrist has been obtained.

Treatment falls into three stages which in practice overlap :—

1. *Restoring sufficient mobility to enable the defect to be corrected.*
2. *Acquiring voluntary control over the movements producing correction.*
3. *Establishing new postural reflexes.*

Mobility. This is limited to an extent sufficient to prevent correction in only a proportion of patients. It is of importance particularly when there is thoracolumbar kyphosis or limitation of extension at the hips.

There are three causes of loss of mobility, more than one of which may be present at the same time :—

(*a*) *Structural Changes* in the shape of the vertebræ, as in thoracolumbar kyphosis, cannot be altered by treatment. The object of remedial treatment is to develop the best posture that is possible in the circumstances.

(*b*) *Contracted Ligaments and Joints Capsules* may limit movements of the vertebræ, hips or feet sufficiently to interfere with correction. Stretching them is a matter of difficulty, indeed it is doubtful if it can be done at all, and when it has apparently been achieved there is no real evidence that ligaments, not muscles, were the limiting structures. Forced passive movements under anæsthesia result in tearing and do more harm than good. The most hopeful approach is by prolonged traction, e.g. head suspension when the spine is involved. Active movements carried to their extreme range and made in a deliberate, controlled, rather than a violent manner may also be worth trying.

(c) "*Shortened Muscles*" hinder the correction of many defects. The process of increasing the length of a muscle is often called "muscle stretching," but this is hardly the right description because, as far as is known, muscle fibres cannot be stretched—they have to be made to relax more fully. This is not only of academic importance but also has a direct affect on treatment. The physiological response of muscle to stretching is contraction. Passively stretching a muscle calls into action this "stretch reflex" and makes the muscle contract more: it can only help to lengthen a muscle when it is gentle, continuous and prolonged.

The best method is to make use of the active relaxation of the muscle that occurs reflexly when its antagonist contracts. When a "free" movement is made, that is one without resistance, the muscle does not relax completely but maintains sufficient tone to control the joint concerned. But when a movement is made against resistance, the muscle can relax completely because control is obtained by pressure between the resistance and the contracting muscle. Hence to "stretch" a muscle, its antagonist must be made to contract against resistance, and to continue to work against the resistance after the extreme of movement is reached. For example, if the leg is allowed to hang over the edge of a couch whilst the patient lies supine upon it, the movement is favoured by gravity and the flexors have to contract to control it; but if one leg is extended backwards whilst the patient stands, gravity resists the movement and the flexors are able to relax (Fig. 31).

Voluntary Control. The movements necessary to correct a postural defect are easily learnt when there is adequate mobility, but care must be taken to study the mechanics of the defect and ensure that the proper groups of muscles are used. For example, when the pelvic inclination is increased, the glutei are the right muscles to restore it to normal. The abdominals, which contract synergically with the glutei, help to restore the contour of the abdomen but they do not materially affect the pelvis. The glutei are also used to correct pes valgus by externally rotating the hips.

New Postural Reflexes. Reflexes are established only as the result of the habitual use of the new posture—this is the final aim of remedial work. The role of exercises is often misunderstood. An exercise consists in making a specified movement which begins in a particular position and finishes usually in the same position. Frequent repetition leads to a habit that facilitates performance of the movement. This habit is composed of two parts; firstly, assuming the position in which the movement begins and ends, and secondly, making the movement itself. The first teaches the desired posture and a ready return to it at the end of the movement, whilst the second teaches control of posture during movement and in varying conditions of balance. The mere making of movements is not the object of exercises; it is the way they are made that matters and the patient must be watched the whole time to ensure that the correct posture is held throughout.

Exercises are used in the earlier stages of treatment to increase mobility and ensure voluntary control over the movements correcting a defect.

Later, they should be designed to teach the maintainance of posture in all conditions of balance and during the ordinary movements of life. It must be remembered that a correction of, say, the pelvic inclination has to be held whilst walking, and that the poise of the head and shoulders is of importance not only when standing, but also during common-place movements like getting up from a chair. Exercises should therefore include such ordinary movements, and once the new posture has been learnt it should be held whatever movements are made. Shoes with heels of the customary height may usefully be worn part of the time.

Learning to walk with the feet and legs corrected does not present



FIG 31

great difficulty but it has to be taught specifically. The patient first learns when standing to rotate the legs out at the hips to make the patellæ face straight forwards; the friction between the feet and the ground prevents the feet turning out and they are automatically restored to their proper shape. Next he learns to keep the patellæ facing forwards whilst walking, and finally he is taught to hold the feet corrected when they are off the ground by using the tibialis posterior and peroneus longus muscles.

Patients when given exercises to do at home tend to concentrate on the easier at the expense of the harder. It is doubtful if any exercises other than just holding the corrected position should be done when alone, except perhaps those for restoring mobility. Exercises of no special value should be avoided; an example is walking round the room on the outer borders of the feet which teaches the use of a wrong posture, and because it is easy to do, it gives the less intelligent patient a false idea of what is required.

Success or failure in treatment depends on the extent to which the co-operation of the patient is obtained. The enthusiasm, understanding and personality of the teacher have full scope in work of this kind. The patient has somehow to be made to *want* to get better. During the remedial class he is taught how to get into the new posture, and how to hold it in a variety of conditions: the habit becomes permanent only if he continues to try after the class is over, and success is impossible if he drops back into the old posture as soon as he is out of the class-room. It is difficult to sustain interest and enthusiasm, even during class, by giving dull, routine exercises, and much ingenuity is required to introduce variety. Music can be used freely, and with suitable patients ball-room dancing is a useful variation. It so happens that the training for classical ballet requires movements that are readily adapted for correcting postural defects. In the absence of other facilities ballet dancing may well be prescribed for musical children, provided extreme external rotation of the feet is avoided and work on the "pointes" excluded, and it has the added advantage of giving poise and grace as well as correcting posture.

CHAPTER II

BACK PAIN

Back pain might almost be described as a universal symptom for it occurs with every variety of ailment from renal calculus to intervertebral disc protrusion, from heart failure to osteoarthritis. The severity of pain in the back is even harder to assess than pain elsewhere. There is no method of gauging it and reliance has to be placed on objective signs such as the manner in which it is recounted, the facial expression, and the extent of interference with the habitual mode of life. Almost everyone has backache at some time or other, and some have it more or less continually, but only a proportion of sufferers complain of it. Neither the intensity of the pain, unless it be of extreme degree, nor its duration, are in constant proportion to their objective effect and it is easy to form a wrong impression. The frequency with which symptoms in the back and a neurotic personality co-incide is notorious, but the difficulty of cure by psychological methods is equally well known. Back pain is a psychosomatic problem, and whether the symptoms are slight or severe, whether the diagnosis is "fibrositis" or sciatica, it is almost certain that sooner or later there will be psychological implications. It is, however, most dangerous to assume that it is entirely psychological just because the patient happens to be of an emotional nature and no organic cause can be discovered. There is probably an organic basis to nearly every complaint of pain in the back even though the symptoms are extravagant. But whatever the nature of the pain, be it predominantly organic or psychogenic, it is equally serious to the patient and just as worthy of cure.

Classification

Pain in the back may be caused by disease or disorder in function of any structure in the back, that is to say by the vertebræ and intervertebral discs, by the joints and ligaments, and by the muscles and nerves controlling them. There is just as great a variety of disorders as at the joints of the limbs, but because the spine is less accessible to examination than a superficial joint like the knee, diagnosis is very much more difficult and there is little precise knowledge of the pathology. The diagnosis of "slipped disc" that is now so often invoked to account for low back pain is grossly overworked, and many of the explanations as to how such a lesion causes pain lack substantiation and can only be regarded as fanciful. Many workers are investigating the problem and gradually a few more or less distinct syndromes are emerging. At the present time, however, it is unusual for

an accurate diagnosis of the exact lesion to be possible and treatment has, of necessity, to be based on probabilities. If progress is to be made with this difficult subject, it is essential that everyone advising these patients should be quite clear what they are doing or they will mislead both themselves and their patients. It is better to admit ignorance than to retard progress by inventing theories merely for the sake of making empirical treatment appear rational.

Classification is necessary to reduce discussion to order, but it has to be clinical because there is insufficient knowledge to formulate one based on etiology or pathology. The approach adopted here is regional with subdivision into acute and chronic. These terms refer to the speed of onset and duration of the pain, the distinction being made for convenience in treatment. There is no sharp dividing line. Acute pain includes all cases of abrupt or rapid onset and short duration, whilst all those of longer duration, whether or no there have been remissions, are regarded as chronic. Sciatica has been placed under a separate heading because it is by no means always accompanied by low back pain, and because only few of the causes of low back pain give rise to sciatica.

cervical	acute stiff neck
	chronic pain
thoracic	acute pain
	chronic pain
low back pain	acute lumbago
	chronic low back pain
coccydynia	
sciatica	

Acute Back Pain. Pain in the back of rapid onset and not associated with demonstrable organic disease is a distinctive clinical problem. It occurs most frequently in the cervical and lumbar regions, but occasionally also in the thoracic spine. The pain comes on quickly and often disappears in a few days, even without treatment. There may be no further attacks, but sometimes there are a few over a period of years. If, as may happen, the attacks become frequent, or the pain persists, the condition merges with that described as chronic back pain.

The ætiology, in many instances, is quite unknown but it is clear that it is not always the same. It can seldom be discovered during a first attack, and therefore the likelihood of recurrence cannot be foretold. It can sometimes be determined in retrospect on those occasions when the pain becomes chronic. Suggested explanations of the isolated or occasional acute attack of apparently spontaneous onset include nipping of a fringe of synovial membrane and subluxation of an intervertebral joint, but there is no real experimental or pathological evidence in support. In the cervical spine, X-rays sometimes show an abnormality in the alignment of the vertebræ which disappears at the same time as the symptoms (Fig. 32). Acute pain ma;

from a fall. In

rupture of an interspinous ligament caused by lifting a weight with the spine flexed (p. 63). This injury should be recognized when possible because it does not respond so readily to treatment. Sudden protrusion of an intervertebral disc may cause acute pain in the neck or low back without radiation to the arm or leg; the diagnosis cannot, however, be confirmed with certainty without operation, and it is most doubtful if it is at all common.

Young adults and those of early middle-age are specially liable to disorders of this group, although they are not uncommon at any age. The onset is frequently associated with minor trauma, such as a jerk when getting on to a moving bus. Sometimes there is an abrupt onset during a movement like swinging a golf club, but sometimes pain comes on gradually during the day without any apparent cause, or is first noticed on waking in the morning. Symptoms can be of any degree of severity; during a severe attack the patient is completely unable to move and cannot even change position in bed, but in a mild attack he may complain only of stiffness and pain on making certain movements.

Examination shows spasm of the erector spinæ of one or both sides which limits active movements of a portion of the spine. Passive movements are painful, but with extreme gentleness it may be possible to "coax" quite a good range. Pain at first is localized, but after a time it radiates widely. The point of greatest tenderness corresponds to that of greatest pain, but there is some tenderness over all the muscles in spasm. Radiological examination is usually negative.

Treatment. Most patients recover spontaneously in the course of a few days, or at most a week or two, although pain of lesser intensity may persist until treatment is given. Manipulation usually gives rapid relief, and it is so simple a business that it is welcomed by most patients.

Manipulation

Manipulation is an important feature of the active treatment of both acute and chronic back pain. It is a simple business and should be part of the therapeutic armamentarium of every doctor and physiotherapist. The methods employed are similar for all parts of the spine; a general account will, therefore, be given here and the details of technique described under the regional headings. No satisfactory reason has so far been advanced to explain why manipulation often relieves pain, nor is it likely that the problem will be solved until the causes of the pain are better understood.

The indications for manipulation are *firstly*, pain of rapid onset in any part of the back. The first attack often responds more dramatically than subsequent ones, often to a single manipulation. The more abrupt the onset, the greater the chance of relief. The pain does not disappear immediately after manipulation, although the patient is often aware of a difference in its character, and as a rule there is gradual improvement until after a day or two nothing remains but a little soreness in the muscles. *Secondly*, manipulation is often of value for chronic back pain. Usually it can be carried out by the physiotherapist as part of the routine treatment but sometimes manipulation under anæsthesia is desirable.

There are two important pre-requisites to manipulation. The first is a full neurological examination to exclude pressure on the spinal cord· I have no knowledge of damage to the cord resulting from manipulation provided this precaution has been taken and a gentle technique has been used. The second is a radiological examination to exclude disease of the vertebræ.

The technique of manipulation is subject to considerable individual variation and only one or two methods out of many are described for each region. The general principle, however, remains the same and the knack

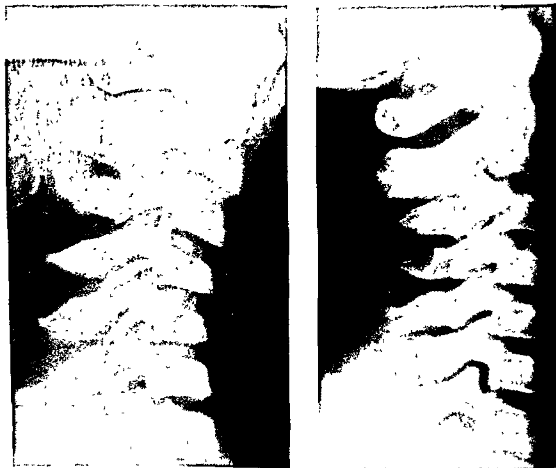


FIG 32 A boy aged 13 hurt his neck "ragging" with a friend
Left on admission *Right* after traction for 48 hours

is learned quickly. The first essential is complete relaxation. This can usually be obtained without an anæsthetic, provided the patient has full confidence in the manipulator. Heat and massage are often a useful preliminary, and traction, either manually or on a special table, may be helpful. An anæsthetic is desirable when there is severe pain and spasm—the need for anæsthesia varies inversely with the skill of the surgeon. No greater force is necessary when an anæsthetic is used, but relaxation is essential and nitrous oxide alone is seldom satisfactory.

as an indication that the joint has been moved. A click can only be obtained a second time from the same joint after a short lapse of time, and the manipulation can be equally effective when no click is heard. The force used is small, the weight of the patient's limb alone sometimes being sufficient to move the joint: to force a movement against resisting muscles is not only painful, but harmful, and therefore the muscles *must* be relaxed.

After relaxation has been obtained, either with or without the aid of anæsthesia, the joint is moved to the extreme of its normal range and then a rather sharp movement of small excursion carries it slightly further. The manipulative movement is made gently but firmly, and it must not be started before the joint is at the extreme of the normal range. If it is begun earlier the patient has time to contract his muscles and check it, and this not only prevents the manipulative movement being made, but also is painful.

CERVICAL

Acute stiff neck

Acute stiff neck is a commonplace disorder. The onset, which is often rapid and sometimes abrupt, may be produced by some ordinary movement of the neck. Not infrequently it starts more gradually, perhaps being noticed first on waking in the morning when the patient becomes aware that the neck is a little stiff and painful: he often puts it down to "sitting in a draught". The symptoms get worse during the next few hours and may become bad enough to cause considerable inconvenience; occasionally the pain is really severe and it is difficult even to turn over in bed.

Examination shows spasm of the muscles of the neck; in a severe attack all the muscles of both sides are involved, but in a mild one the spasm may be limited to a small area. There is tenderness over one or two of the intervertebral joints and to a lesser extent over the whole of the muscles in spasm. Pain may radiate over any area within the distribution of the cervical roots; it is often referred to the back of the head when the upper cervical joints are affected, and to the shoulders when the lower joints are involved. Active and passive movements of the neck are limited in some directions; rotation is usually greatly restricted and causes the patient to turn the whole trunk when looking to one side.

A rather alarming form sometimes occurs in older children. The onset is abrupt and results from a minor injury, say when diving. A fracture of the spine or other serious damage is naturally suspected but the X-rays show only an alteration in the ordinary curve of the cervical spine (Fig. 32). The radiological appearance returns quickly to normal after treatment, which should be by continuous traction rather than manipulation.

Disease of the vertebræ is excluded by radiography. It is unusual, in an acute attack, to find the narrowing of the intervertebral spaces and the accompanying degenerative changes in the bodies of the vertebræ that give rise to chronic pain. Particular care is necessary in children because of the possibility of atlanto-axial dislocation which sometimes occurs without other symptoms after tonsilitis or one of the exanthemata. A

major protrusion of a cervical intervertebral disc is excluded by the absence of pain referred to the arm and hand, and by a negative neurological examination (p. 319).

Treatment. A majority of patients recover fairly quickly without any treatment, but an attack, particularly a first attack, can usually be terminated quickly by manipulation. A thorough clinical and radiological examination must be made first. If there is any doubt as to the diagnosis as was the case with the patient illustrated in Fig. 32, manipulation should be postponed and continuous traction of 3–5 lbs applied to the head by means of a halter. It is an advantage to precede manipulation by manual traction for a minute or two.

The neck is manipulated most easily with the patient supine on a couch and the head and neck projecting over the end. Since the head is supported only by the surgeon's hands, care must be taken not to remove the support for an instant, even when the position of the hands is being changed, because the patient will not relax unless he feels absolutely secure. The range of passive movements of the neck in this position is greater than the active range when standing up. Rotation is possible through more than 90° in each direction and side-bending can be continued until the ear touches the shoulder.



Fig. 33 Manipulation of the cervical spine—rotation

The manipulative movements usually carried out are a continuation of rotation and side-bending beyond the normal active range. For rotation to the right, the head is supported on the left hand with the occipital protruberance lying in the cleft between the thumb and index finger and the side of the face resting on the fingers The fingers of the right hand are placed under the chin and the head is rotated gently to the right whilst slight traction is made. When the extreme of movement is reached, but not before, a very small additional twist is made sharply (Fig. 33). The position of the hands is reversed for rotation to the left.

Side-bending cannot be carried to an extreme because the shoulder is in the way, and therefore the neck is bent round a fulcrum. The head is supported on the left hand as before and carried well to the left ; the radial border of the forefinger of the right hand is pressed firmly against the transverse processes of the vertebræ at the affected level. The right hand is held rigid with the thumb extended so as not to press on the trachea The neck is then bent to the right whilst the right hand is pressed to the left, and when the extreme of movement is reached, a small thrust is made with both hands simultaneously (Fig. 34).

Chronic pain

Persistent pain in the neck is a common and often intractable complaint of middle-aged and elderly people. It can be due to many of the causes listed for chronic low back pain on p. 59, but the more usual are *spondylosis* and *myofascial painful areas*. Spondylosis either with or without associated disc protrusions may also cause pressure on nerve roots with pain radiating to the shoulder, arm and hand; although pain in the neck may be a prominent clinical feature, this condition is more conveniently described with other causes of pain in the arm on p. 319. It can usually be recognized because it gives rise to symptoms only when



FIG. 34. Manipulation of the cervical spine—lateral bending

there are demonstrable X-ray changes. Radiological examination is therefore indispensable and oblique films must be included to show encroachment on the neural foramina.

Myofascial Painful Areas (p. 69) occur alone or in association with spondylosis. They are found in any part of the trapezius, in the deep muscles of the neck, and along the occipital ridge. Pain is continuous, but not severe, and it is made worse by worry or fatigue. It may radiate to other areas in the same dermatomes, particularly over the back of the head, and it is a common cause of headache which can be most troublesome in susceptible subjects. The only positive clinical finding is the presence of localized tender areas in the characteristic situations.

Treatment is not difficult when the painful areas occur alone. They can usually be removed by deep massage and friction, if necessary preceded immediately by an injection of novocain. The problem is less easy when there is associated root pressure because the pain soon returns. Attention is, of course, directed towards eliminating the basal cause, but it is well worth while to treat also the local myofascial symptoms. Indeed, it is sometimes remarkable how much benefit is derived just from eliminating these painful areas and the associated muscle spasm.

THORACIC

Acute pain

Pain of sudden onset is less frequent in the thoracic region than in the more mobile parts of the spine. It is similar to that in the cervical spine and sometimes starts abruptly from just coughing, sneezing or stretching the arms above the head. Any joint, intervertebral, costovertebral or costotransverse may be involved. Sometimes the pain radiates along an intercostal nerve to the breast or the front of the chest, or along the first thoracic nerve to the ulnar border of the arm and hand. Pain may also be felt at the areas supplied by the lower intercostal nerves thus simulating visceral disease; there may even be reflex spasm of the abdominal muscles. Breathing is often painful and, when the upper vertebræ are involved, movements of the neck are limited and painful.

Examination shows spasm of the erector spinæ, tenderness over the affected joints, and limitation of movement, particularly rotation. Diagnosis has to be made from disease of the vertebræ and ribs and therefore X-rays must be taken before treatment. Other causes of pain in the back such as aneurism must also be excluded.

Treatment. Spontaneous recovery is slower than with the cervical spine and manipulation is the treatment for choice. An anæsthetic is seldom required as nearly all the joints are readily moved by the methods to be described. The exceptions are the first and second costovertebral joints which require a different and more difficult techinque. Injection of novocain around the painful joint may be helpful.

There are many ways of manipulating the dorsal spine but that shown in Fig. 35 (right) gives least discomfort to the patient. He lies supine on a couch and his hands, with fingers interlaced, are placed behind his neck and his elbows brought together in front of his face; his forearms are held with the surgeon's left forearm and hand, and his elbows pressed against the surgeon's chest. The upper part of his spine is then passively flexed and the ball of the surgeon's right thumb placed under the painful joint. The patient is then told to let his shoulders drop back on to the couch, and the moment his muscles are felt to relax, but before he actually moves, the manipulative movement is made by an upward thrust of the right thumb and a downward thrust of the chest in the direction of the patient's arms. The common mistake is to allow the spine to extend; it must be kept flexed all the time.

There is a method of manipulating the intervertebral joints with the patient sitting which nearly always succeeds when relaxation cannot be obtained in other ways. The patient is held as shown in Fig. 35 (left), the surgeon's hands being locked behind his neck as in a "double Nelson," he is lifted an inch from the stool and then told to sit down; when he tries to do so, his muscles automatically relax, and then a sharp movement of small excursion is made forwards with the knee and backwards with the hands. If the patient is too heavy to lift alone, help can be given by two assistants each supporting one of his elbows.

Chronic pain

Chronic pain in the thoracic spine occurs at all ages and it is more often possible to make a proper diagnosis than is the case with low back pain. The commoner causes are listed below in order of age at onset—

Children	tuberculosis
	adolescent kyphosis
	ankylosing spondylitis
	scoliosis and other deformities
	myofascial painful areas
	tumours and diseases of bone
	referred visceral pain
	senile osteoporosis
Old age	senile kyphosis

Most of these conditions are readily identified with the aid of X-rays and are discussed in the next chapter. Pain in the absence of any such





Fig 35 Two methods of manipulating the dorsal spine

demonstrable disorder, although it is perhaps less common than at other parts of the back, does occur, and the pathology is equally obscure. At times it is quite severe, and it may be referred to the distribution of an intercostal nerve. The response to manipulation is favourable.

Myofascial painful areas may be found alone or accompanying spinal deformity or disease, and are not uncommon. A usual site, and one which is frequently overlooked, is beneath the vertebral border of the scapula; this area is exposed to palpation when the patient draws the scapula forwards by placing one hand on the opposite shoulder (p. 69).

LOW BACK PAIN

Low back pain is one of the commonest complaints met in practice and its causes are so diverse as to make systematic description more than difficult. The symptoms have little variety, physical signs are few, radiological findings are equivocal and pathological information is negligible. There is little agreement as to ætiology which is often speculative, and as to treatment which is usually empirical. The situation is further obscured by the psychological aspect which intrudes with every patient either as an ætiological factor, or because of the mental effect of long-standing pain. The confusion has been increased, rather than diminished, by the discovery that intervertebral disc protrusions, which are a common cause of sciatic pain, can also give rise to low back pain without sciatica. Medical men, for so long without any idea as to the real pathology of low back pain, jumped at the notion of a "disc lesion" as a gift from heaven, and many of them have exploited it to such effect that both they and the public have come to regard low back pain and a "slipped disc" as synonymous. This is, of course, nonsense, and although a little progress has been made, we are still so far from understanding the problems concerned that it is impossible to present a clear-cut picture.

Patients with low back pain consult a great variety of physician and surgeons, and no two, even amongst those practising the sam speciality, hold identical views. There are some who regard th psychological aspect as paramount, some incriminate mainly the viscera others search only for toxins and hidden peculiarities of metabolism, an yet others think only of intervertebral disc lesions. But the patient shoul be looked at as a whole so that all these views, which may be but differen facets of one problem, can be seen in proper proportion. There is no panace for backache. Successful treatment is based on the painstaking considera*tion of the individual patient and involves not only the temporary relief o* pain, but also removal of the underlying cause to prevent recurrence.

Examination

A full history is essential to the proper assessment of the patient. It often provides the key to diagnosis because the physical findings, which have little variety, can only be interpreted in relation to the history. The story should commence with the first occasion pain was felt and continue through remissions and exacerbations to the current attack. Details of other illnesses and the obstetric history may be important, and enquiry into the family history and environmental conditions help in assessing the patient's personality. Physical examination requires great care or an entirely false impression may be obtained. No reliable conclusion can be drawn from one or two isolated observations, and negative findings are as important as positive. The whole patient must be examined, not only the part of the back complained of, or some causal fault may be overlooked. The patient should be entirely undressed, or wear no more than a "triangle," because posture and movement cannot be judged with half the body

concealed—even panties cover the sacroiliac and hip joints. Mistakes in diagnosis are less likely if a full routine is always followed.

Scheme of Examination.

Standing	Body build and musculature.
	General posture.
	Deformities.
	Site of pain and direction of radiation.
	Active movements—flexion
	extension.
	side bending.
	rotation.
Lying supine.	Posture.
	Hips—all movements.
	Spine—passive movements—flexion.
	rotation.
	Lasègue's test.
	Abdominal palpation.
Lying on side.	Rotation.
Lying prone.	Posture.
	Tenderness.
	Hips—extension.
	Spine—extension.
	Femoral nerve stretch test.
C.N.S.	Routine examination.
Rectum.	Digital examination.

The patient is first examined standing. He is asked to point to the site of pain and also the direction in which it radiates. The general body build and posture are noted and also temporary alterations in posture, such as obliteration of the lumbar curve or a list to one side.

Active movements are examined both when standing and sitting. Flexion, extension, side-bending and rotation are carried out in turn and restriction of movement and pain are noted. The movements of the back should have a smooth rhythm in which each vertebra takes a share; abnormality is specially noticeable during flexion when a section consisting of two or three vertebræ may be fixed by spasm and fail to take part in the movement. Ability to touch the ground with the fingers is no indication of a normal spine because this achievement depends to some extent on the relative length of the hamstrings, and some people can touch the ground when the whole lumbar spine is rigid. Returning to the upright from flexion or extension can be more painful than the original movement, and often there is a sort of wriggle as a painful arc of movement is passed. There may be a difference in the range of movements when standing and sitting; for example, the hamstrings limit forward rotation of the pelvis at the hips when standing, but not when sitting with the knees bent, and therefore the strain on the sacroiliac and lumbosacral joints is greater when standing.

The way the patient gets on to the examination couch, the posture he adopts on it, and how he moves from one position to another give valuable information about the severity of the pain. Conscious or unconscious exaggeration of symptoms may be betrayed by the way he lies. Thus a patient who appears completely unable to hollow the back when sitting may lie on the couch with the hips and knees bent and the lumbar curve exaggerated. Movements of the hips must always be examined because limitation at the hips affects the posture of the spine.





Fig 36. Examining the spine in flexion

The methods of examining flexion of the lumbar spine, and rotation in flexion, are illustrated in Fig. 36. Both movements are confined to the lumbar and thoracic spine provided the legs are moved together. If, however, movement of the pelvis and lumbar spine is restricted by holding one leg flat on the couch, flexing the other leg places a torsional strain on the sacroiliac as well as the lumbosacral joints.

Rotation is also carried out lying on the side. When the spine is extended, the lumbar and thoracic joints are moved as well as the sacroiliac joints, but movement can be restricted to the sacroiliacs by drawing up the lower leg to flex the lumbar spine (Fig. 40).

Extension is examined with the patient prone. Lifting one leg alone causes a forward torsion strain on the sacroiliac joint. Lifting both legs

together extends the lumbar and thoracic spine without straining the sacroiliacs (Fig. 37).

Points of greatest tenderness, which are elicited with the patient prone, should be distinguished from the widespread tenderness of muscles in spasm. It is important to identify tenderness over the interspinous ligaments as distinct from the spinous processes themselves. This can be done, if the subject is not too fat, by placing a couple of pillows beneath the abdomen to flex the lumbar spine. Myofascial tender areas may be





Fig 37 Examining the spine in extension

found at points remote from the region where pain is felt, and pressure at such points often causes referred pain. They may be found only after a diligent search, going over the muscles inch by inch.

There are two tests of special value in low back pain but they are only of significance when interpreted in conjunction with the other findings:

Laségue's sign (straight-knee leg raising test) is elicited with the patient supine, one leg being raised with the knee straight, whilst the other remains flat on the couch. Normally the leg can be lifted 90° or more, the exact distance depending on the hamstrings. Limitation of movement and pain are usually present in low back pain and sciatica, but not necessarily to an extent proportionate to the severity of the symptoms. When the leg is raised until pain is just felt, dorsiflexion of the foot increases the pull

on the sciatic nerve without altering the tension of the hamstrings, and this increases sciatic pain but not pain from other causes (Fig. 38).

Femoral nerve stretch test is performed by flexing one knee whilst the patient is prone (Fig. 39). This pulls the femoral nerve downwards in



FIG 38 Lasègue's sign.

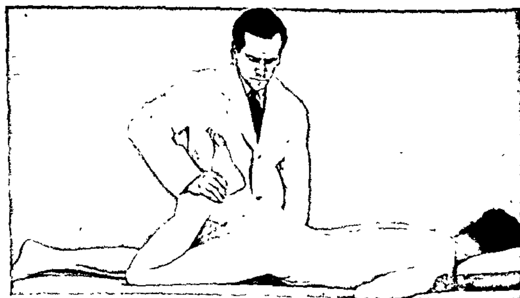


FIG 39 Femoral nerve stretch test

the same way that straight-knee leg raising pulls down the sciatic nerve; i causes pain of a "neuralgic" type in front of the thigh when there i interference with the third and fourth lumbar nerve roots.

The same manœuvre may, when the nerve is free, cause pain in th back. Full flexion of the knee stretches the anterior muscles of the thigl and rotates the pelvis forwards thus increasing the lumbar curve. Thi causes pain in those conditions in which extension of the sp... is painful

Acute lumbago

Acute lumbago, that is to say low back pain of abrupt or rapid onset, is a real clinical entity even though it may ultimately become chronic. Knowledge as to the cause is unfortunately no more accurate than is the case with acute pain in the cervical and thoracic regions, and the ætiology is usually unknown. It is true that many people treating it are dogmatic about the pathology (and the more dogmatic they are, the bigger their practices grow), but no convincing evidence has yet been offered to show that any of the alleged lesions are regularly present.

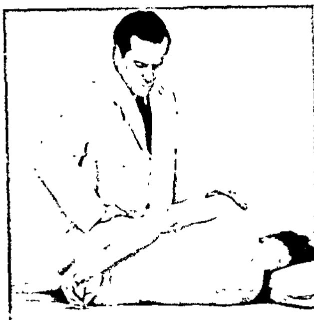


FIG 40 Only the sacroiliac joint is moved because the lumbar spine has been fully flexed by bending the right knee up to the chest (cf Fig 48, p 73)

Intervertebral disc protrusion may be an occasional cause of acute lumbago without sciatica, but the findings in those patients submitted to operation show that it is not common. Because, on occasion, a subsequent attack is accompanied by sciatica, this is no proof that the previous lumbago was due to a disc protrusion. It is just as likely that there was some other lesion, such as a ruptured interspinous ligament, which predisposes to intervertebral disc injury.

Acute sacroiliac strain, until recently as popular a diagnosis as "slipped disc" is today, is now known to have been just as grossly overworked. It does occur occasionally, most often after parturition or an abdominal operation, when it may be noticed either at once, or on getting up for the first time a few days later. Sacroiliac pain can be differentiated from pain originating in the low lumbar joints by the procedure illustrated in Fig. 40. One knee is bent up to touch the chest, thus flexing the spine fully and fixing the lumbar joints; rotation of the ilium then moves the upper sacroiliac joint and this causes pain when the joint is disordered. Sacroiliac pain can also be reproduced by pressing together or separating the anterior superior iliac spines.

Rupture of an interspinous ligament is a fairly common cause of acute lumbago (p. 63). This injury occurs as the result of a fall in the sitting position, or from lifting a weight with the spine flexed. It is important to recognize it at once because it does not respond to the usual treatment for acute lumbago. The diagnosis can be made when the point of greatest tenderness is localized to an interspinous ligament, and the pain is temporarily relieved by an injection of novocain into the ligament.

Clinical features. A classical example of acute lumbago is the man who is engaged in an occupation such as golf and is smitten by a sudden pain in the loin; he is unable to move and is carried home where he remains in bed in great pain which only subsides after some days. The onset is often less dramatic and the pain may be noticed first on waking in the morning, or it may come on during the day without known cause and increase rapidly in intensity. The severity of the pain varies greatly. The patient is often unable to stand upright, and sometimes he can hardly walk. When less severe, there is difficulty in standing or sitting for long, in twisting round or turning in bed; straightening up after sitting in a chair is particularly troublesome. Pain is often widespread and may radiate to the groin, the outer side of the hip or the back of the thigh.

Examination shows spasm of the lumbar muscles, usually on one side more than the other; occasionally it is extreme and involves even the abdominal muscles. Tenderness is greatest over the affected joints but after a time it becomes more diffuse. Active and passive movements of the lumbar spine are greatly restricted and painful.

Treatment. As a rule the pain goes spontaneously in the course of a few days or weeks. It is helped by rest in bed and by any measure that relieves spasm, and therefore analgesics are indicated; relief has been known to follow administration of an anæsthetic without any other interference. Injections of novocain sometimes help, but during the most acute phase they may be followed by increased pain.

Manipulation is a simple method of treatment and relieves many attacks almost at once Even when the pain is very severe, and it can be so bad as to cause considerable alarm, manipulation may be equally dramatic. An anæsthetic is not often necessary, but whether one is used or not, the manipulation must be gentle. Skill is required to persuade an apprehensive patient to relax when he is getting considerable pain each time he moves. The manœvre most often required is forward rotation of the ilium and lumbar spine. This is most easily performed with the patient lying on the side as described on p. 73. The reverse movement, backward rotation of the ilium, is occasionally necessary. It is carried out with the patient lying on the side and the hips slightly flexed; the anterior superior spine is pulled backwards with one hand whilst the ischial tuberosity is thrust forwards with the other.

Traction is another satisfactory procedure (p. 74). Special apparatus is desirable, but not absolutely essential. A few patients have learned, of their own accord, to relieve their pain by hanging from a beam by the hands and allowing their trunk muscles to relax!

CHRONIC LOW BACK PAIN

The generalizations about low back pain made on page 52 apply with added force when the pain is chronic. Assessment of the severity of the pain, the cause of it, and the treatment best fitted to the individual patient remains one of the most difficult problems in clinical medicine. It is by no means always possible to arrive at a precise diagnosis but the attempt must be made, if only as a matter of personal discipline. It is only too easy to declare that nearly every patient is suffering from a disc protrusion, or whatever else one's particular hobby-horse may be. Because pain in the back, in many instances, has to be treated empirically, and because unorthodox practitioners are often successful in relieving the pain, it is easy to accept facile theories as to pathology, instead of insisting on demonstrable facts. It is far better to admit ignorance than to mislead both one's patients and oneself.

Diagnosis

The more common known causes of chronic low back pain are listed below, but others are not yet defined. Most of the known causes have an established and easily demonstrable pathology, but a few, such as acute and chronic strain on ligaments, are still theoretical although they are based on sound physiological and pathological observations.

chronic strain on ligaments—	muscular fatigue
	postural defects
	anomalies of development
	acquired deformities
acute strain on ligaments	"sprung back"
	unstable lumbar vertebra

spondylosis
osteoarthritis
myofascial pain
intervertebral disc protrusion
fracture of bodies or appendages
spondylolisis and *spondylolisthesis* }
ankylosing spondylitis } *See* Chapter III
diseases of the vertebræ }

Radiological examination is essential in every case to exclude major disease of the vertebræ and such disorders as ankylosing spondylitis, spondylolisthesis and fracture. The X-ray findings must be interpreted with great care and in conjunction with the clinical findings. The presence of spondylosis does not necessarily mean that it is causing pain; slight narrowing of a single disc space is not proof that there is a disc protrusion; and anomalies of development are so often present in the absence of symptoms that they must be incriminated only with reluctance. The demonstration of instability of a vertebra requires a meticulous radiological technique and a heavy expenditure of time and films, but both are necessary when the clinical picture points to such a lesion

Chronic Strain on Ligaments

Ligaments, as explained on page 1, are liable to hurt when subjected to continuous strain. They are normally protected by the muscles which maintain the posture of the joints at an intermediate point in their range of movement, but if there is absolute or relative muscular insufficiency, excessive strain falls on the ligaments and joint capsules. This may occur during periods of chronic ill-health, particularly if there is already a postural or structural defect causing the muscles to work at a mechanical disadvantage. People with a minor defect often remain symptom free for many years but break down after some additional strain, and symptoms, once established, may persist indefinitely.

Pain in or around a joint gives rise to muscle spasm in the attempt to protect the joint from strain. The spasm may be localized at first to the deep muscles which span a single joint, but later it spreads to the more superficial and longer muscles that cover a number of joints and the pain becomes more widespread. Protective muscle spasm continues as long as the joint lesion remains unrelieved and a vicious circle is established—pain—protective muscle spasm—pain.

Pain may be of any degree from a mild ache to disabling severity. In the earlier stages there is often freedom from pain on getting up in the morning, but backache develops d[illegible] the day; it is made worse by fatigue and relieved by resting with the back supported. It is not accurately localized, and is not reproduced by passive movements if examination happens to be made at a moment when there is no pain. The tendency over years is for the pain to become gradually worse and more continuous until eventually it is constant. Not infrequently a minor strain causes an exacerbation that brings the patient to consult his doctor.

[illegible]lar Fatigue. Fatigue, whether acute or chronic, is a common p[illegible] backache because tired muscles are unable to protect the [illegible]n. [illegible] be[illegible] no great importance when the ligam[illegible] condition is present, strain may be [illegible]rn. [illegible]n. It is, therefore, often noticed that [illegible] is [illegible]usually hard day's work, or a long journey by rail or car. [illegible]ame reason backache of whatever cause tends to be worse at the end of the day. Fatigue is sometimes found to have a definite cause, such as undernutrition; or there may have been too early a return to the onerous duties of a working housewife after parturition, or after an illness or operation, particularly an abdominal operation. Often, however, there is no cause that can be remedied; the fatigue of an overworked woman causes backache, and the backache increases fatigue.

Postural Defects. The posture of people with a poor habitual stance is such that the joints are near to one extreme of the range of movements and this reduces the excursion of the joints before the ligaments come under tension. Postural defects are not necessarily accompanied by pain, but it often happens that a minor illness or some unusual strain precipi-

the onset of symptoms. Those of slender build are more prone to this type of disorder, and stiff backs cause more trouble than supple ones.

Many patients with a bad posture and chronic backache complain also of abdominal symptoms. The abdominal symptoms are sometimes attributed to visceroptosis, and the visceroptosis is alleged to cause backache, but there is no need to assume a causal relationship. The faulty body mechanics, the visceroptosis, constipation, indigestion, backache and the accompanying general fatigue and ill-health are all part of one syndrome. It is a false approach to try to cure backache by a surgical attack on the abdomen, or by embarking on the Herculean task of cleansing the colon.

Congenital Anomalies. Minor anomalies of the vertebræ are so usual that a variation from "normal" is said to be detectable in about one



FIG 41 Asymmetry of the lumbosacral joints The right joint is nearly in the sagittal plane, whilst the left is in the co[illegible]al plane

half of the population. There is some evidence, although it is not conclusive, that they occur more frequently in painful than in painfree backs, and that they do play a part in the production of backache. Great care must, however, be taken before accepting an anomaly as the cause of pain in any particular instance.

Asymmetry of the posterior intervertebral joints is common. These joints, in the lumbar region, normally lie approximately in the sagittal plane to facilitate flexion and extension. but frequently one or more are placed obliquely (Fig. 41). An element of rotation is therefore superimposed on the normal movements and might, in theory, give rise to abnormal strains. This is often alleged to be a cause of pain but it has never been proved.

A narrow disc between the fifth lumbar vertebra and the sacrum is very often seen. Some degree of narrowing was found by Campbell Golding in 44 per cent of patients referred for reasons other than low back pain; it cannot be regarded as a pathological finding in those complaining

of low back pain unless there is other evidence to incriminate it. Narrowing at other levels is, however, more likely to be significant (p. 67).

Number of mobile vertebræ. Normally there are five lumbar and five sacral vertebræ, but sometimes the arrangement is four lumbar and six sacral, or six lumbar and four sacral. An additional lumbar vertebra increases the length of the most mobile part of the spine, and therefore increases the leverage on the lumbosacral joint. An additional sacral vertebra is seldom of significance provided the whole of the fifth lumbar is incorporated in the sacrum, but unilateral sacralization causes an important alteration in mechanics. A common variation of this type is for one of the



FIG. 42. Unilateral sacralization of the fifth lumbar vertebra

transverse processes of the fifth lumbar vertebra to be large and linked to the sacrum by a diarthrodial joint (Fig. 42). The axis of movement during side-bending is then shifted from the sagittal plane to this joint and the excursion of the opposite side of the vertebra is increased. This may cause strain, and consequently pain, on the side opposite to the sacralization. The additional joint is also subject to the same causes of pain as any other joint.

Spina bifida occulta (p. 118) is not a cause of low back pain.

Acquired Deformities. These give rise to back pain for the same reason as postural defects—the mechanical disadvantage at which the back is working causes undue strain during times of stress, usually at the site of a change in curve. Adolescent kyphos[illegible]s of the hip, etc., are, therefore, frequently [illegible] the vigour of youth, the muscles are abl[illegible]igaments against strain in spite of the restricted range of movements, but pain often starts during middle age, coming on either gradually, or after some specific strain.

Acute Strain of Ligaments

A notable advance in knowledge of the etiology of low back pain has become possible as the result of observations made by Floyd and Silver* in the course of an electromyographic investigation into the action of the erector spinæ muscles. They have shown that when the spine is in process of bending, the muscles are working actively to lower the trunk, but as soon as the spine is fully flexed, muscular activity ceases entirely and further flexion is prevented only by the tension of the ligaments, particularly the supraspinous and interspinous ligaments. This happens whenever the spine is fully flexed, and regardless of the position of the hip joints: the ligaments are, therefore, under tension when bending to the ground, when sitting in a slouched position, or when leaning forwards over a sink or an ironing board. During recovery from the flexed position, the erector spinæ do not contract until the back begins to straighten. Thus, if a weight is being lifted from the ground and the hips are straightened before the back, the erector spinæ remain inactive and the strain is taken entirely by the ligaments (Fig. 14). In this position the ligaments are unprotected, and therefore easily damaged. In a similar way they may also be injured by a fall onto the buttocks with the legs stretched out in front, as in falling down stairs.

"Sprung Back." One of the commoner complaints of younger adults is low back pain of comparatively low intensity which is relieved by rest, but which recurs at frequent intervals. P. H. Newman†, who has aptly named the condition "sprung back", considers that it is due to partial or complete rupture of the supra- and interspinous ligaments resulting from an injury of the type described above.

The patient is usually between fifteen and thirty-five years of age, but sometimes older, and more often a woman than a man. There may be a history of pain, sometimes years previously, following a fall, or after lifting a weight, but often the cause is forgotten. There is complaint of pain in the low back which may radiate to the buttocks and thighs, and is described as a dull or nagging ache. It is annoying rather than severe, and is made worse by bending and lifting, or by working in a stooping position, as with much housework, and by sitting with the back unsupported. The symptoms are relieved by rest or by physiotherapy, but they return after any slight strain, such as working for a long time with the back bent, or driving all day in a car.

The physical signs vary with the amount of pain at the time of examination. There may be spasm of the erector spinæ with limitation of movement and pain at the extremes of movement. Often, the only positive finding is tenderness which is greatest over the supraspinous ligament between the fifth lumbar and first sacral vertebræ, and sometimes the ligament immediately above. These ligaments can be palpated when the patient is lying prone with two pillows under the abdomen to flex the

*W F Floyd and P H Spencer-Silver *Lancet* 1951, I, 133

†P H Newman *Journal of Bone and Joint Surgery*, 1952, 34B, 30

spine and separate the spinous processes. An injection of novocain into the ligament relieves the pain temporarily. The X-rays frequently are normal, but when there is a complete rupture, a film taken with the spine fully flexed may show an increased separation between the spinous processes.

A back once damaged in this way is not easily cured because it is so hard to get at the injured ligaments. A partial rupture often heals with a scar which is painful whenever it is placed under tension; it is not accessible to massage or manipulation. A complete rupture leaves an attenuated ligament which remains a permanent weakness; the spinous processes are no longer tied together, hence a fresh strain may spring apart the posterior

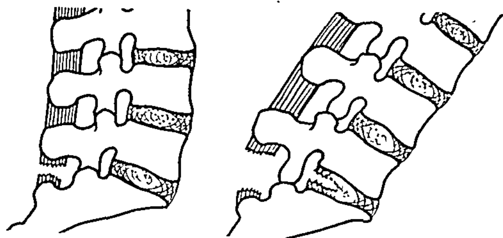


FIG 43 *Left* "Sprung back" The interspinous ligament has been ruptured by a flexion injury *Right.* A subsequent strain on the unprotected joint has ruptured the intervertebral disc (*After P. H. Newman*).

margins of the vertebral bodies sufficiently to rupture the posterior longitudinal ligament and annulus fibrosus (Fig. 43). A sprung back is, therefore, a common precursor of disc protrusion and a damaged interspinous ligament can often be observed at operation for this complaint.

Treatment is most difficult because the symptoms are seldom severe enough to call for a major procedure such as spinal fusion, and even a surgical corset may not be tolerated. It is not often practicable to do more than give advice as to how strain on the affected interspinous ligaments may be avoided (p. 74).

Unstable Vertebræ. This is a condition in which one of the lumbar vertebræ shifts backwards and forwards on the vertebra below it. The movement usually takes place between the fourth and fifth lumbar vertebræ, or the fifth lumbar and the sacrum, but sometimes the higher lumbar vertebræ are involved. The displacement is more often in a forwards direction and occurs during flexion of the spine, the position being restored to normal in extension. Sometimes the shift is permanent, a condition often known as *pseudo-spondylolisthesis.* Movement backwards, which occurs when the spine is extended, is referred to as *reverse spondylolisthesis.*

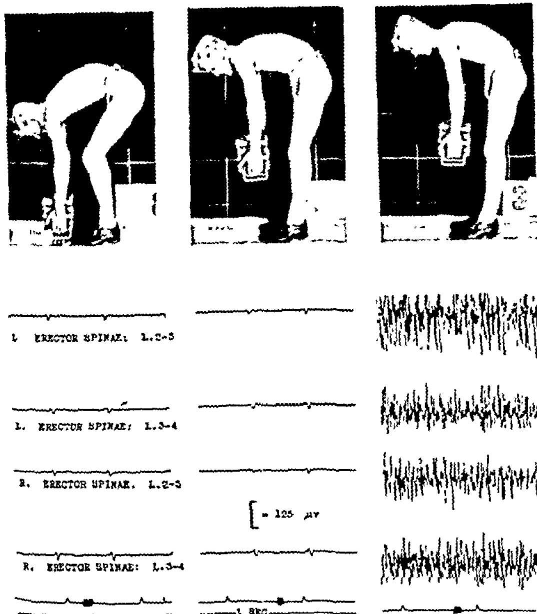


Fig 44 Electromyographs of the erectores spinae with synchronized photographs made whilst lifting a weight of 20 lbs (*By courtesy of Dr P H Spencer-Silver*)
Left The spine is fully flexed and the muscles are inactive
Centre The hips are being extended but the spine remains flexed and the muscles inactive.
Right The spine is being extended and the muscles are contracting vigorously

The cause of the instability is not fully understood, but the displacement would not be possible unless there were some derangement of the intervertebral disc. There must also be an abnormality of the neural arch to permit the shearing movement. There is no defect of the pars interarticularis, such as occurs in true spondylolisthesis. Macnab* has, however, shown that there is often an alteration in the plane of the articular processes. The inferior articular processes, which normally point almost vertically downwards, are found in many of these patients to slope obliquely

*I. Macnab *Journal of Bone and Joint Surgery*, 1950, 32B, 325

backwards and downwards, an arrangement that facilitates forwards displacement.

The signs and symptoms are variable, the clinical picture resembling that seen in sprung back. The pain is usually of gradual onset and at first is intermittent, later becoming more persistent. It is worse after exercise, and when first moving after resting. Sciatic pain, often with evidence of



FIG 45 Unstable vertebræ

Left In extension the third lumbar [illegible] and the [illegible]

Right Alignment is restored in flexio[illegible] and the Schmorl s nodes

root involvement, is a common but late complication and may be due to associated disc protrusion.

The diagnosis depends upon expert radiography, and unless the X-rays are accurately centred in a precisely lateral plane, a misleading picture may be obtained. The amount of displacement is seldom greater than ¼-inch. It often varies with the position of the spine and therefore exposures are made with the patient standing and the spine flexed, upright and extended.

Treatment involves immobilization of the spine (p. 76). Spinal fusion is a satisfactory procedure when the other joints of the lumbar spine are normal. If there are pathological changes elsewhere, fusion is useless and little more can be done than to provide a surgical corset. When there is an associated disc protrusion, removing the protrusion should relieve the sciatica, but it cannot cure the backache.

Spondylosis

The condition
associated with re-a
is commonly termed
which affects the diathrodial, posterior intervertebral joints, and it is not

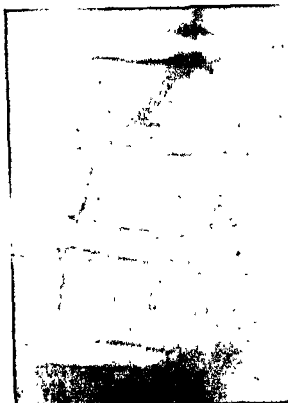


FIG 46 Spondylosis All the intervertebral disc spaces are narrow, there is reactive lipping of the bodies of the vertebræ and the fourth lumbar vertebra is displaced slightly backwards on the fifth The second lumbar shows evidence of old osteochondritis juvenilis

ynonymous with disc protrusion. A common cause, as is explained on 'age 94, is dehydration of the nucleus pulposus. The effect of dehydration s to reduce the buffering action of the nucleus so that pressure is no longer listributed evenly over the bodies of the vertebræ. The stresses at the eriphery of the bodies, where the discs are attached to bone, are therefore ncreased, and the natural reaction to this is new bone formation. There re also secondary degenerative changes, and often calcification, in the ongitudinal ligaments.

The radiological appearance in spondylosis consists in narrowing of the spaces between the bodies of the vertebræ together with new bone formation around the periphery, and often sclerosis of the opposing surfaces of the bodies (Fig. 46). Narrowing of an intervertebral space, even when only one is involved, is an indication of disc degeneration; this can be, but is not necessarily, accompanied by a protrusion of the disc—it is impossible to diagnose a disc protrusion by simple X-rays.

Spondylosis is often symptomless, its presence being discovered by chance in X-rays taken for other reasons. When symptoms are present, they are indeterminate in nature. The backache closely resembles that due to other causes, although pain is perhaps more often referred to the groin. When only two or three discs are affected, there is little alteration in the range of movements, but multiple disc degeneration causes considerable restriction. The diagnosis is made radiologically, but spondylosis is so often symptomless that its presence in an X-ray must not be accepted as the cause of pain until all other possibilities have been excluded.

Mobilization of the spine by physiotherapy may give relief from pain when the symptoms are mild, but care should also be taken to avoid placing unnecessary strain on the back (p. 73). In more severe cases, immobilization is often necessary and this should be by means of a surgical corset. Spinal fusion is undesirable, even when only one disc appears to be affected, because it may cause pain in the neighbouring joints.

Osteoarthritis

The articulations between the vertebræ are of two distinct types; those between the bodies are symphyses, whilst those between the articular processes are diarthrodial joints. Osteoarthritis is a disorder of diathrodial joints, and since the posterior intervertebral joints are the only joints of this type in the spine, the term arthritis should be reserved for them. The joints between the bodies are subject to an entirely different series of changes which are described under the heading of spondylosis; to refer to these changes as osteoarthritis is confusing an already complicated subject. Spondylosis with the accompanying formation of bony outgrowths on the bodies of the vertebræ may occur at the same time as true osteoarthritis, but it is just as common alone, and it is not necessarily a cause of pain. Osteoarthritis of the spine results from the same causes as elsewhere—interference with the joint mechanics—and therefore it occurs when there is alteration in the alignment of the spine which prevents the opposing surfaces of the joints from fitting and moving congruously. Disturbance in the alignment by gross deformity, such as structural scoliosis, or unreduced congenital dislocation of the hip, results in many joints being involved; but when the alteration in alignment is localized, as after a crush fracture, only one pair of joints is affected. The alignment is also altered when an intervertebral disc is greatly reduced in thickness, hence spondylosis and osteoarthritis not infrequently are present at the same time.

Osteoarthritis of the sacroiliac joints is rare and the slight lipping at the inferior borders of the joints often seen in radiographs seldom has any connection with pain.

The symptoms of osteoarthritis are pain and stiffness. The pain is worse on movement and after exercise; it is relieved by rest although it is often worse on first moving after resting for a while. It does not usually interfere with sleep, but with advanced disease it may be troublesome at night. Examination shows protective muscle spasm, tenderness, pain on

active and passive movements of the affected joints, and a reduced range of movements. Neither the history nor the physical signs are precise enough for an accurate clinical diagnosis and a patient should never be told he has osteoarthritis unless there is definite evidence of involvement of the posterior intervertebral joints. The typical X-ray changes are irregularity in the outline of the joint, subchondral sclerosis and lipping (Fig. 47).

Myofascial Pain

Localized painful and tender areas in muscle, tendon and fascia are a very real cause of pain but the pathology is quite unknown. The terms "sensitive deposits" and "fibrositis" which are often used to describe them are misleading because there are no deposits and there is no inflammation. Areas of myofascial pain are common in connection with the extensor muscles of the trunk. They may occur either as an isolated phenomenon, or when there is muscle spasm due to some other condition such as spondylosis.

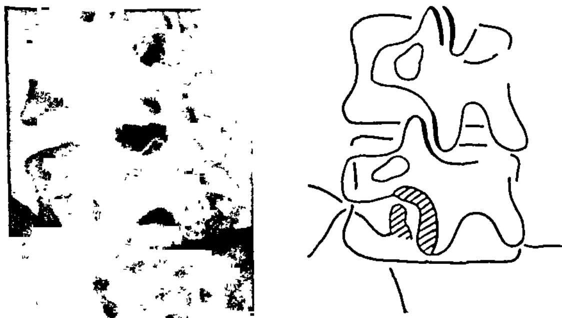


FIG 47 Osteoarthritis of the posterior lumbosacral joints The interpretation of oblique X-rays is discussed on page 122

Various explanations have been suggested :—

(*a*) Inflammation around sensory nerve endings: there is no histological evidence of this.

(*b*) Local metabolic changes in the tissue fluids around sensory nerve endings: that permanent relief often follows local infiltration with saline or novocain is in favour of this theory.

(*c*) Local areas of spasm involving only a few muscle fibres: alterations in electromyograms have been observed.

(*d*) Focal sepsis: the association is often noticed but a causal relationship is seldom proved.

(*e*) A "rheumatic" manifestation: it adds nothing to our knowledge to attribute this condition to "rheumatism" which is just as vague a concept.

Myofascial pain occurs most frequently at places where muscle fibres arise from bone or fascia without intervening tendon. The common sites in the low back are in the origins of:

the glutei from the dorsum of the ilium and the margin of the sacrum,
the erector spinæ from the dorsum of the sacrum, the iliac crests and the lumbar fascia and
the quadratus lumborum from the twelfth rib.

Pain may be felt locally but often it is referred elsewhere and patients are not always aware of the existence of tender spots which will only be discovered by careful palpation. Pain from the gluteal region may be referred over the buttocks and down the back of the thigh, just as pain from the vertebral border of the scapula is referred down the arm. In young people with tenderness over the posterior part of the iliac crest, iliac apophysitis is an alternative diagnosis; this condition requires no treatment and clears up spontaneously when growth is complete.

Pain which closely resembles myofascial pain also occurs in connection with the small, movable, encapsulated lobules of subcutaneous fat often to be found in the lower back. The lobules are usually painless but sometimes they are exceedingly tender. There is no histological difference between painless and painful lobules.

The hernias of fat described by W. S. C. Copeman may be an occasional cause of pain. They appear to consist either of subfascial fat passing through a small hiatus in the superficial fascia, or else of lobules of fat herniating through their own covering membrane.

TREATMENT is worth while even when a more serious condition is present; indeed, relief from the myofascial pain alone may be enough to give reasonable comfort. Infiltration with novocain is often successful A long needle is inserted and moved about until the patient announces that the actual spot is touched, and then the injection is made. A few cubic centimetres of fluid may be sufficient, but several injections at intervals of a few days are sometimes required. Injections should be followed by massage given, when possible, before the effect of the local anæsthetic has worn off. Subcutaneous lobules of fat can often be broken up by massage or, failing that, by an injection of novocain. Excision of a lobule of fat may occasionally be desirable.

Local injection of hydrocortisone into myofascial tender areas is in experimental use and the results are encouraging.

Intervertebral Disc Protrusion

Intervertebral disc protrusion must be accepted as a possible cause of low back pain *without* associated sciatic pain because of the occasional findings at operation, but it is unlikely to be very common. It is true that some surgeons and many unorthodox practitioners believe that disc protrusions account for most of the more severe pains in the back, but no acceptable evidence has been produced to support this extreme view.

Disc protrusions, in theory, can cause pain in the back by pressure on the longitudinal ligaments of the spine, the meninges or nerve roots.

An anterior protrusion pressing on the anterior common ligament might cause back pain but not root pain, but a posterior protrusion could give rise to either. In the absence of pain referred to the leg, a clinical diagnosis is next to impossible. There is no characteristic history. Recurrent attacks of lumbago followed finally by sciatica are explained as rationally by other theories. The physical signs—pain and muscle spasm—are common to back pain of many types. Simple X-rays, even when there is a protrusion, are often negative; narrowing of the disc space is not diagnostic of a protrusion (p. 67). A positive diagnosis can be made only at operation, and perhaps by myelography.

Disc protrusion causing sciatic pain can often be relieved by rest in bed, by manipulation and by traction. It may therefore be expected that the same procedures will relieve pain in the back without sciatic pain, but having the same cause. Treatment of this type is likely to be prescribed when there is pain in the back of uncertain etiology, as is the case when it is due to disc protrusion.

Fracture

Compression fractures of the bodies of the vertebræ are a potent, but often unnecessary, cause of low back pain. Recent fractures should seldom be overlooked if an X-ray is taken whenever there is tenderness over a spinous process after an injury which might cause violent flexion, such as a motor-car accident. Healed fractures give rise to pain either because of the nature of the injury, or because of the treatment. Certain fractures, and the ordinary crush fracture with anterior wedging is not one of them, cause chronic pain at the site of fracture because of the nature of the injury; spinal fusion is likely to help. It is more common to find pain at the lumbosacral junction resulting from a fracture at a higher level treated by prolonged fixation in hyperextension in a plaster jacket. Such cases are difficult to treat, partly because of the psychological overlay. Fusion of the vertebræ at the level of the fracture is clearly useless and the approach must be by active mobilization.

The appendages of the vertebræ are fractured nearly as often as the bodies. The common injury is a fracture of one or more transverse processes, often by avulsion of the tips. Fractures of the pedicles, articular processes and spinous processes also occur but they are much harder to demonstrate radiologically, and oblique films, perferably steroscopic, may be required. Repair is usually by fibrous tissue and the radiological appearances of fracture may persist throughout life. Tenderness and pain, including pain in the appropriate passive movements, must be correctly localized before a suspected fracture is incriminated.

Most recent fractures of the appendages, as well as old fractures giving rise to chronic symptoms, should be treated actively. Recent fractures of the pedicles are an exception and they should be immobilized in a plaster cast until union has occurred, possibly three months; non-union leaves the spine unstable and will probably give rise to pain (*see* spondylolisis, p. 120).

TREATMENT OF CHRONIC LOW BACK PAIN

The approach to a patient with chronic back pain is beset with pitfalls and the greatest caution must be exercised because an initial error can precipitate the sufferer onto the downhill path of chronic invalidism. No rule of thumb methods suffice, and no routine treatment can be laid down even for clearly defined pathological conditions; the hackneyed saying that it is the patient and not the disease that is treated is never more significant than here. Each individual is a separate problem the key to which is concealed in a complicated equation with his mental make-up, his environment and the physical lesion as the unknown factors. The greatest chance of success lies in the deliberate evaluation of the whole position by the patient's own doctor, and the greatest danger is a spot diagnosis by a specialist at a single interview.

There are, in general terms, three methods of approach—move it, keep it still or cut it out.

(1) *Mobilization* includes all measures directed to increasing the range of painless movements, principally physical therapy.

(2) *Immobilization* is intended to relieve pain by preventing painful movement.

(3) *A surgical attack on the lesion.* This is only possible in certain instances, for example disc protrusions and fractures of the vertebral appendages.

The treatment selected must be related to the severity of the pain, the occupation of the patient and his personality. The severity of pain is so difficult to assess that it is quite easy to prescribe treatment that is more irksome than the pain it is intended to relieve. For example, many people would prefer to modify their activities to some extent, and have an occasional course of physical treatment to relieve an exacerbation, rather than wear a surgical corset or submit to a spinal fusion. Most patients are first treated by mobilization, and immobilization is considered only when this has failed; surgery is the last resort.

Mobilization

Minor Backache in young adults may be caused by a definite lesion such as a ruptured interspinous ligament, or spondylolisthesis. Not infrequently, however, there is no demonstrable pathological condition, and no history suggesting a soft tissue injury. In these cases, the symptoms are usually relieved by rest with heat and massage as adjuvants, but unless the underlying cause can be removed, recurrence is likely. Postural defects and minor fixed deformities can be corrected by remedial measures. When there is ill-health due to under-nutrition, or occurring after illness, the remedy is obvious but practical advice is difficult to give—what can be done to relieve the backache of a woman who works sixteen hours a day looking after her children, her husband and her home? People of sedentary occupation such as clerks and typists are often short of exercise and benefit from general physical training; "keep-fit" classes of one sort or another are available in many districts for both sexes and all ages, but the mistake of ordering exercises for an already overtired patient must not be made.

In middle aged and elderly people the lesser degrees of backache are often but an early stage in the development of pain of greater severity, and usually associated with some demonstrable disorder, for example spondylosis. Temporary relief may be given by physical treatment, but it is just as important to prevent the symptoms from becoming worse. Treatment therefore follows the general lines of severe backache, particular attention being paid to avoiding strain.

SEVERE BACKACHE, whatever the cause, can often be helped by mobilization and it is usually worth a trial. The actual pain, irrespective of the changes X-rays may show in the bones, originates in the soft tissues, and it is the soft tissues that require attention. The approach is by the ordinary methods of physical treatment—heat, massage, manipulation, traction and exercises. These are all standard procedures, but it is noticeable that the results vary considerably with the individual physiotherapist.

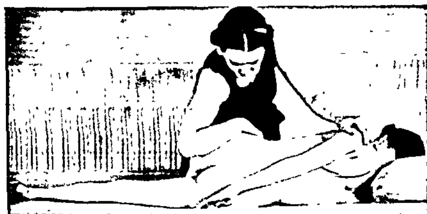


FIG 48. Forward rotation of the left sacroiliac joint and lumbar spine (cf Fig. 40, p 57).

Radiant heat often gives sufficient relaxation, presumably by inducing a sense of comfort, to enable massage to be effective. Short wave diathermy is used when it is desirable to apply heat to the soft tissues around the joints of the spine.

Dry cupping is so old-fashioned a method of reducing muscle spasm that one hesitates to mention it, but the relief it brings is often remarkable. With the more severe degrees of muscle spasm, such as are sometimes seen in acute lumbago, it is a valuable preliminary and it may give enough relaxation for massage to be practicable.

Massage is a most important part of treatment. There is no good explanation as to why it helps so much, and perhaps because of this, it is prescribed less frequently than it used to be. Massage, to be effective, must be really deep, and since this is painful and leaves the muscles sore, it should not be used more often than alternate days.

Manipulation is carried out using the general technique already described (p. 45). There are many variations in detail but a simple method is with the patient lying on his side with the upper leg hanging over the edge of the couch and held as shown in Fig. 48. The spine is gently rotated

until the extreme of movement is reached and then, when relaxation is complete, a slight downwards thrust is imparted to the ilium. No force is required and the final movement must never be made before the muscles have relaxed. An anæsthetic is seldom necessary and the procedure should be within the competence of every doctor and physiotherapist. It is only when relaxation cannot otherwise be obtained that an anæsthetic is given, and then care must be taken to ensure that the force applied is no greater than when the patient is conscious.

Traction is a good method of moving joints when this is restricted by muscle spasm or some other, and probably unknown, cause. It is most effectively applied on a special table to which the patient is attached by a harness around the pelvis and thorax. The more elaborate installations provide an intermittent pull by means of an electric motor.

Exercises are designed to prevent muscle wasting, as normally happens to the muscles controlling a disordered joint. It may also be possible, with great persistence, to strengthen the muscles and give better protection against strain. The beneficial effect is, however, limited by the reflex inhibition of the erector spinæ in full flexion (p. 63).

It is difficult to relieve chronic backache whilst the patient continues to work in the same conditions that produced it, whether as a labourer, an engineer or a housewife. Two or three weeks rest is therefore important, and it greatly increases the prospect of successful treatment. If rest can be obtained in no other way, and this applies particularly to the housewife, a period in hospital is desirable.

Prophylaxis. It is almost as important to prevent backache from recurring as to relieve the present attack. Many people suffering from recurring backache manage to regulate their lives in such a way as to reduce greatly the frequency of attacks. This is not possible with all occupations, especially those involving bending and heavy lifting, but work entailing standing can often be modified with the help of a co-operative employer; even the provision of a stool is often a great help. Although with most types of recurring backache attacks are induced by flexion, pain is sometimes caused by extension, particularly in people with a "sway back" posture who find standing for any length of time most trying.

Flexion is normally required for a great many jobs. Examples in the home are washing-up and ironing; in the garden, bedding out plants and working at the potting bench; in the factory, work at the fitter's bench and the machine tool. It is quite an effort to alter habits, but it can be done and patients at the Middlesex Hospital are given an illustrated leaflet to help them (Fig. 49) When the height of the work cannot be altered, it may be possible to sit on a stool; when work at ground level is essential it should not be continued for too long, but alternated with some other job; bending to the ground should always be done by flexing the knees—this is most important when lifting a weight. The professional weight-lifter always keeps his back hollow because he knows that otherwise he will damage it; the stevedore and the labourer usually do the same, and when they fail to, they pay for it by injuring their backs.

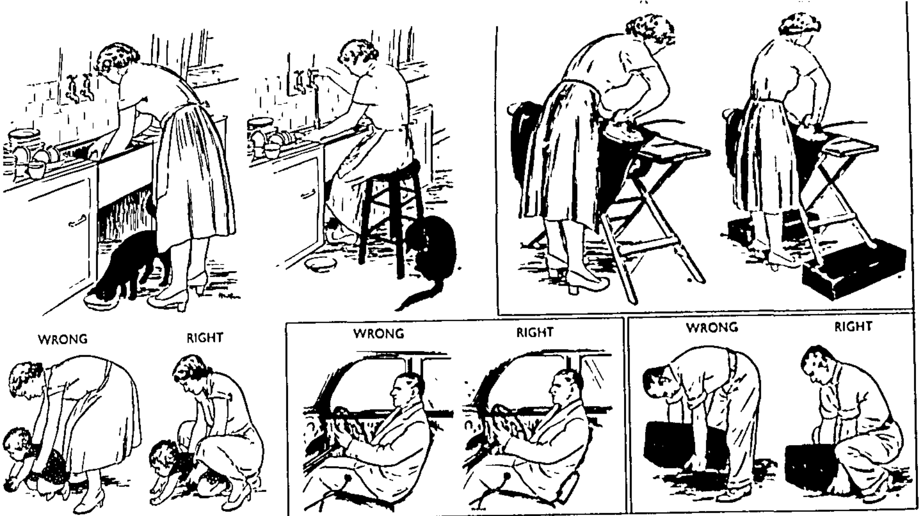


FIG 49 How to avoid straining the back (extracted from a leaflet issued by The Middlesex Hospital)

"The ligaments of the spine can be strained by working or lifting with the back bent. You should avoid, as far as possible, standing for a long time or lifting a weight with your back bent. The right way to lift is to bend the knees and hips and keep the back hollow. If you form the habit of doing all your ordinary jobs like this, you may prevent yourself from getting further attacks of pain.

"At night lie on a firm mattress, and if the springs of the bed sag, place some boards beneath the mattress. This will prevent the spine being strained whilst you are asleep."

These precautions will reduce the frequency of attacks but, because of the human element, they cannot prevent them entirely. When an attack does occur, treatment must be begun as quickly as possible—the sooner is starts, the quicker it is relieved. Patients have, therefore, to be taught that they should not put up with their pain for as long as they can, but seek treatment at once, the very day it starts. Hospitals that are enterprising enough to arrange for such patients to have immediate treatment save them many weeks of disability, and save the staff of their physiotherapy departments many hours of work.

Immobilization

Immobilization can be effected by wearing a spinal support or by spinal fusion. A spinal support, to be effective, must restrict movement of the painful joints and therefore is irksome. Spinal fusion is a major operation involving weeks in bed followed by months wearing a spinal support, and is of value only in certain circumstances.

Spinal Support. The indication is pain that cannot be relieved by mobilization. The object of the support, when used for low back pain, is to restrict movement of the lumbar spine, and since there are many joints deeply covered by soft tissues, and since the trunk is a heavy object, strong and cumbersome machinery is necessary. Various types of support are available, but even the best do not prevent all movement. The most useful appliance for general use is a surgical corset. A rigid spinal brace, for example a brace of the Fisher type, is very unpleasant to wear and now is seldom prescribed.

SURGICAL CORSETS are made by many manufacturers but not all are [illegible] et may [illegible] al bars [illegible] to the pelvis is achieved by a strong pelvic band joined behind to the spinal bars and passing forwards at a level midway between the anterior superior [illegible]ac spines and the great trochanters to fasten in front; it may be outside or inside the fabric of the corset, but unless it is kept tight, the whole contraption is useless. The spinal bars, usually two or four in number, are made of light steel and placed on each side of the spinous processes; they must be accurately shaped to the curves of the back so as to be comfortable to lean against when sitting. Attachment of the thorax to the spinal bars is by means of the fabric of the corset. It must extend well above the ribs in front, in women to just below the breasts; if it is cut lower than the ribs, the spine merely flexes around it and the spinal bars stick out behind. Fixation of the thorax is irksome to many people, but without it, the corset fails in its object. The fabric may be of nylon, coutil or other strong material. If support for the lower abdomen is also needed, the pull should be obliquely backwards and upwards, thus lifting the abdomen and not merely compressing it. Pressure pads incorporated in the corset are not only unnecessary, but may be positively harmful because they can cause atrophy of the underlying structures.

Spinal Fusion. Operative fixation of the vertebræ for low back pain is indicated in patients of stable personality who have pain and disability severe enough to warrant a major operation, provided always not more than one or two pairs of joints are affected. It may, therefore, be desirable in spondylolisis or spondylolisthesis, "sprung back", unstable vertebra, fracture, etc. It is also practised on some occasions when there is associated sciatic pain due to an intervertebral disc protrusion. Fusion is of little value in conditions *already affecting*, or *likely to affect, many joints*, such as spondylosis, because the added strain on the joints immediately above or below the area fused soon makes them painful.

Assessment of the results of spinal fusion is most difficult. Continued pain may be due to the wrong selection of patients, or to failure to obtain



Fig 50 Surgical corset



Fig 51. Plaster corset

fusion by bone. It is almost impossible to tell radiologically if fusion is sound. The method of comparing films taken in full flexion and extension, and left and right sidebending, is not reliable; sometimes they seem to show movement when subsequent operation makes it clear that none is possible, and sometimes they fail to show movement when it is taking place.

The number of methods of spinal fusion is an indication that none can be relied upon entirely. The author prefers an "H" graft cut from the ilium or, when the sacral spinous process is deficient, screw fixation. The after-treatment varies with different surgeons but an ordinary routine involves four to six weeks on the back followed by six weeks in a plaster corset (Fig. 51) and then six months wearing a surgical corset.

Albee's operation, or one of its variations, can be used for any part of the spine except the sacroiliac joints. The spinous processes and laminæ are joined by tibial grafts fastened to them, or alternatively the spinous processes are split longitudinally and the graft placed therein. Firm apposition of the grafts with the host is ensured by wire or screw fixation.

Hibb's operation and others of this type combine intra-articular and extra-articular fusion. Multiple bone chips are raised from the laminæ and interlaced so as to unite into a solid mass. The lateral joints are excised and packed with bone chips, and the spinous processes may be "bent" down to bring them into apposition.

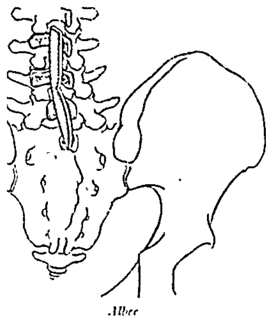
H-graft. The fifth lumbar spinous process is excised and the cortical surfaces are removed from fourth lumbar and first sacral spinous processes, and from the laminæ of the fourth and fifth lumbar vertebræ and the upper part of the sacrum. A rectangular graft of the exact length necessary is cut from the crest or the outer table of the ilium, or from the tibia, and a deep notch is made in each end of it. The fourth lumbar and first sacral spinous processes are then separated by forcible traction and the graft is placed between them. It is usual to pack the space between the laminæ and the graft with chips of cancellous bone, and some surgeons also excise the articular cartilage from the intervertebral joints and pack them with bone. The H-graft is fitted whilst the spine is in full flexion so that when it is extended the graft "takes the weight" and often gives immediate relief from pain. It also immobilizes the vertebræ for long enough to allow the chip grafts to fuse.

Chandler's procedure is a modification of the H-graft. The laminæ are rawed and covered with chips of cancellous bone, two strips of bone cut from the outer table of the ilium are placed alongside the spinous processes on top of the chips, and then two shorter strips are fitted between the spinous processes. Finally, a wire is passed around the spinous processes through holes drilled *in the fourth lumbar and first sacral to* hold the grafts in position. *Newman* has further modified the operation by using ribs from the "bone bank" instead of iliac bone.

Screw Fixation. The cortical bone is removed from the laminæ and spinous processes of the affected vertebræ and the intervertebral joints are excised. Screws 1 to 1½ inches long are passed from the laminæ through each of the joints into the pedicles, and chips of cancellous bone are packed into the joints and placed on the raw surfaces of the laminæ.

Intercorporal fusion is now being performed after laminectomy by excising the intervertebral disc and inserting grafts into slots cut in the bodies of the vertebræ. The procedure is still experimental.

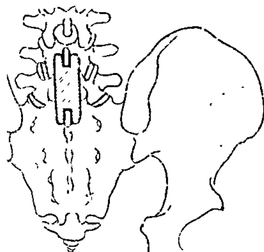
Smith-Petersen's sacroiliac fusion is performed by removing a rectangular plug of bone about 2 inches by 1 inch from the ilium over the joint; the anterior surface of the plug forms part of the posterior surface of the joint. The articular cartilage is removed from the plug and the exposed surface of the sacrum, and then the plug is replaced and firmly impacted with a punch. Plaster fixation after operation is unnecessary; the patient lies on his back on a firm mattress for four weeks and then is allowed up.



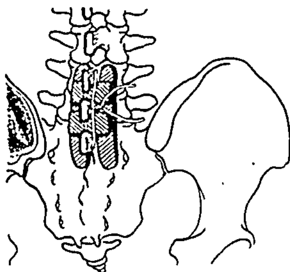
Albee



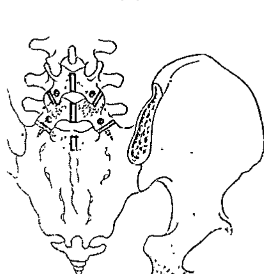
Hibbs



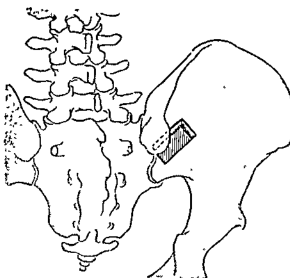
H-graft



Chandler



Screw-fixation



Smith-Petersen

Fig 52 Operations for spinal fusion

COCCYDYNIA

Pain in the region of the coccyx occurs more frequently in women than men; moreover, women of neurotic personality are more often afflicted and this makes it harder to assess the importance of an organic lesion, and more difficult to treat it. The patient often attributes the trouble to a minor injury like a kick or a fall. The symptoms persist indefinitely and are annoying rather than incapacitating. The pain is worse when sitting than when standing, and sometimes when going upstairs, an action which involves the use of the gluteus maximus. Sometimes the only complaint is of a burning or pricking sensation.

The difficulty in treating coccydynia is due partly to inadequate examination. It is necessary to localize exactly the point of greatest tenderness by bi-digital examination with one finger in the rectum.

There are four types of coccydynia :—

(1) *Fracture.* The coccyx or the lower pieces of the sacrum are sometimes fractured by a fall or a kick. Diagnosis must be based on good X-ray evidence because variations in the shape of the coccyx and the number of segments composing it are common and may be mistaken for fracture on casual examination. Sharp forward angulation of the coccyx at the sacro-coccygeal joint is a frequent anatomical variation and is seldom due to injury.

(2) *Sacro-coccygeal Joint.* The ligaments of this joint may be strained by injury just as at any other joint. On bi-digital examination, movement of the coccyx causes pain which is felt at the joint and not where the fingers are pressing.

(3) *Myofascial Painful Areas.* These occur in the attachment of the muscles arising from the coccyx and in the ano-coccygeal body. Pain originating in the ano-coccygeal body is often felt diffusely over the perineum. Tender spots can be accurately localized and pain is caused by direct pressure, not by movement of the coccyx.

(4) *Diffuse Pain* with no localizing physical signs. This is the most distressing form of coccydynia for all concerned. The pain is often described as burning in character, and there is no constant point of tenderness. Infiltration of the entire region with a local anæsthetic may fail to relieve the symptoms even temporarily. The pain is clearly of central origin and peripheral treatment is useless.

Treatment. Coccydynia so often occurs in neurotic subjects that the remarks already made about chronic backache apply with particular force. Organic lesions, however, must not be overlooked because they do respond to local treatment. Well localized tender areas usually disappear after infiltration with novocain or with a small quantity of proctocain, and sometimes manipulation of the sacro-coccygeal joint under anæsthesia is helpful.

Excision of the coccyx should only be advised in carefully selected patients and, on the whole, it does more harm than good. It is indicated after conservative treatment has failed, when there is a fracture, and when there is pain on movement of the sacrococcygeal joint.

SCIATICA

Sciatica is a symptom, not a disease. It is a symptom produced as a rule by mechanical interference with the trunk of the sciatic nerve or its roots at any point subsequent to their emergence from the spinal cord; Until recently there was great confusion about the ætiology of sciatica; a mechanical explanation was accepted only when there was an obvious cause like a massive pelvic tumour or a diseased vertebra, and the great majority of cases were regarded as inflammatory. Mixter and Barr's work on intervertebral disc lesions, which was published in 1934, completely altered the position and since then it has become apparent that an overwhelming percentage are caused by disc protrusions. Primary "neuritis" and "radiculitis," once regarded as common, are now known to be rare.

Although disc protrusions are responsible for a large proportion of cases of sciatic pain, it is always necessary to exclude other possible causes. An abbreviated list is given below.

Root Pressure:

In spinal canal.	Intervertebral disc protrusion.
	collapse of bodies of vertebræ.
	tumours of nerve roots and meninges.
	spondylolisthesis.
In neural canal.	Tumours of nerve roots.
	Hodgkin's disease.
In pelvis.	Impacted tumours.
	local spread of malignant tumours.
	abscess.
In buttock.	Tumours of pelvic bones.
	soft tissue tumours.

Primary Neuritis.

Pseudo-Sciatica.

Pseudo-sciatica is a complaint in which there is no direct interference with the nerve roots but pain is referred to the peripheral distribution of the sciatic nerve or the lesser sciatic nerve, usually from a myofascial tender area (p. 69). The pain is felt at the back of the thigh or leg and somewhat resembles that in sciatica; it is made worse by pressing on the tender spot but it is not increased by coughing or sneezing (i.e. raising the cerebrospinal pressure), and there are no organic motor or sensory changes. Infiltration with novocain always relieves the pain temporarily, and sometimes permanently. Similar "trigger points" are not infrequently found when there is true sciatica, and although treating them may lessen the severity of the symptoms, it will not relieve them entirely.

Intervertebral Disc Protrusions

An intervertebral disc extruding in a posterior or postero-lateral direction into the neural canal may come into contact with the intra- or extra-dural portions of one or more spinal nerve roots causing lumbago and sciatica. There are two types of lesion, one consisting mainly of nucleus

pulposus, and the other mainly of annulus fibrosus, but they are not always clearly differentiated. There is confusion about the nomenclature. Some authors refer to the ordinary lesion of the nucleus pulposus as a herniation of the nucleus through the annulus, and restrict the term disc protrusion to those occasions when a large fragment of the posterior annulus fibrosus has become detached. For the sake of simplicity, both lesions will be called disc protrusions because some part of the disc is certainly protruding into the neural canal.

The commoner type of protrusion occurs when the nucleus herniates through a small tear in the posterior annulus fibrosus, usually in its weaker, lateral portion. The actual protrusion then consists of a core of nuclear material covered with a thin layer of annulus fibrosus bulging backwards into the spinal canal (Fig. 54a). The protrusion is under tension and the core extrudes when the annulus is incised at operation. Occasionally it bursts spontaneously and nuclear material is found free in the spinal

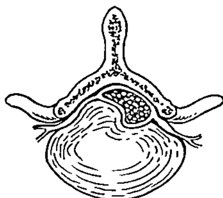


FIG 53 Intervertebral disc protrusion impinging on a nerve root

canal. One or more nerve roots may be in contact with the protrusion an then pain is increased by movement of the back, traction on the nerve or indeed, anything that increases the tension of the nerve root. This is th explanation of pain on straight-knee leg raising, flexing the neck and othe manœuvres which pull the nerve roots, and also on activities which raise the pressure of the cerebro-s in the relative positions of the protrusion and the explains why different patients with sciatica find different postures mor comfortable.

The other type of protrusion consists mostly of degenerate and partl fragmented annulus (Fig. 54b). With recent lesions pain is produced i the same way as the previous type, but in old standing protrusions ther is often much fibrosis involving the surrounding extradural tissues an adjacent nerve roots The nerve roots are anchored firmly and pain caused during movement because they are stretched instead of glidin freely. Very large, centrally placed protrusions may compress the entu cauda equina causing partial paraplegia

ETIOLOGY. The pathological anatomy and etiology of intervertebr disc protrusions are discussed in the next chapter on

Clinical Features

Men are affected more frequently than women, possibly because they are more exposed to trauma. The chief complaint is of pain which in most cases is first felt in the back and later radiates down the leg; sometimes, however, it starts in the leg. The onset may be abrupt, the pain reaching its greatest intensity very quickly, or it may start as a mere ache and increase gradually to a climax. There can be repeated attacks of lumbago without sciatic pain before the latter is finally felt. Repeated attacks of sciatica with intervals of comparative freedom are common, and sometimes a single attack of lumbago, or lumbago and sciatica, is followed by many years of complete freedom before another bout supervenes.

About half the patients with sciatica have had an injury shortly before the first attack of pain. Subsequent attacks may start after a minor twist of the back, for example when gardening, or there may be no apparent reason. A history of trauma does not help with diagnosis because minor

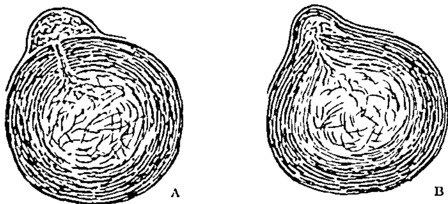


FIG 54 Intervertebral disc protrusions (cf Fig 58)
A Consisting mainly of nucleus pulposus
B Consisting mainly of annulus fibrosus

After Bradford and Spurling

injuries are very common in the normal course of life, and because the incident which injures the annulus fibrosus may be widely separated in time from the actual protrusion of the nucleus and the onset of symptoms.

Symptoms. PAIN is the outstanding feature, the one thing that really matters to the patient. There may be only a dull ache, or there may be a stabbing, neuralgic pain that shoots the length of the limb with seering agony. At its least, the pain is a constant source of annoyance; at its worst, it is of almost intolerable severity, all ordinary movements are prevented, the victim changes position only slowly and deliberately, rest is impossible and even a cough is fearful.

Pain may be felt in the back or in the area of distribution of the sciatic nerve, but more frequently it is in both at once with one or other predominant. The pain is often described as commencing in the lumbosacral angle and radiating through the buttock and down the back or outer side of the thigh to the knee; thence it spreads down the calf to the ankle and through the heel to the sole, or to either side of the dorsum of the foot; sometimes it shoots along the leg, and sometimes it is felt as a spasm

gripping the calf like a vice. It is made worse by walking or any form (exercise, and by straining, coughing or sneezing. Rest generally relievi it somewhat although spontaneous movements during sleep may cause spasm. It is generally eased by flexion of the knee and hip, and certai "trick" postures such as rotation of the back combined with extension (the hip on the bad side, or elevation of both arms, occasionally give relie

PARÆSTHESIÆ are very common. Numbness, tingling and pins ar needles may be felt in any part of the limb, particularly the calf and foo and are increased by those movements which cause pain.

WEAKNESS of the muscles of the buttock or calf is sometimes conside able enough to be noticed by the patient.

Physical Signs. POSTURE. The normal lumbar concavity is ofte absent or reversed, and frequently the spine is inclined to one side (*sciat scoliosis*). The patient leans slightly forwards and most of the weight carried on the sound leg. The affected leg may be slightly flexed at th hip and knee, and the heel raised from the ground.

Sciatic "scoliosis" is not a true lateral curvature but a list of the trun to one side at the lumbosacral junction (Fig. 55). The position is adopte unconsciously, presumably because it relieves the pain, and is present whe sitting or lying as well as when standing. The direction of inclination ma be either towards or away from the affected side and is probably dete mined by the relation of the nerve root to the protrusion. Occasionall when the protrusion is nearly central, the patient is able to change th inclination from one side to the other voluntarily (*alternating sciat scoliosis*); this is effected by leaning forwards and giving the back a sor of wriggle. The site of pain changes and moves sometimes to a differer part of the same leg, and sometimes to the other leg. Alternating sciati scoliosis is invariably caused by an intervertebral disc protrusion.

MOVEMENTS. There is obvious spasm of the lumbar muscles. Whe standing, all movements of the lumbar spine are restricted, and pain is fel at the extremes of movement; as a rule limitation of flexion is more marke than limitation of extension, but occasionally flexion is fairly free an extension is more difficult. Side bending and rotation are not usuall restricted in both directions by the same amount; sometimes movemer is more free towards the affected side, and sometimes away from it.

Movements such as undressing, getting up from a chair and lyin down are made with great caution, and it may be impossible for the patien to lift the bad leg on to a high couch without the aid of his hands. He lie with hip and knee flexed and often is unable to place the leg flat. Turnin over is a matter of difficulty and the whole trunk is moved as a solid piece Lying prone is painful unless the hip can be fully extended and it may b necessary to place a pillow under the pelvis during examination.

TENDERNESS. Pressure on the fourth or fifth spinous process is nearl always painful and may cause pain to be referred to the leg. There is ofte tenderness at the lumbosacral angle, over the sciatic notch, and along th course of the sciatic nerve in the thigh and calf, and times th tender spots in the muscles on the dorsum ilii.

Laségue's Sign (Fig. 38, p. 56). Pain is almost invariably caused by raising the straight leg when lying supine. Sometimes it begins when the foot has been lifted only a few inches from the couch, but sometimes the leg can be raised 70° or 80°. Raising the sound limb whilst the affected limb remains flat may also cause pain. The pain has the same character and distribution as that previously experienced by the patient and it must

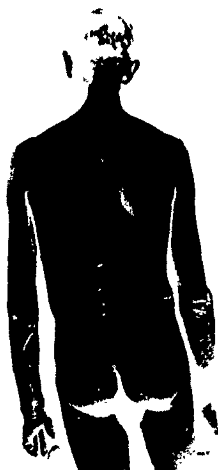


FIG 55 Sciatic "scoliosis"

not be confused with the feeling of tightness behind the knee and thigh that is normally felt when straight leg raising is forced.

Pain is also caused by raising the straight leg to a point just short of that which produces pain and then dorsiflexing the foot at the ankle, because this increases the tension on the sciatic nerve. Pain is sometimes caused by flexing the neck whilst the leg is raised, probably because the dura mater is dragged upwards thus increasing pull on the nerve root. Straight leg raising is painful in disorders of the lumbosacral and sacroiliac joints as well as in sciatica, but it is not aggravated by dorsiflexion of the foot or flexing the neck.

Femoral nerve stretch sign. (Fig. 39, p. 56). This is the counterpart of Laségue's sign and is elicited by flexion of the knee whilst the patient is prone. When positive, it suggests involvement of the third or fourth

lumbar roots by a protrusion of the second or third lumbar discs. It is occasionally positive with protrusions of the fourth disc, and rarely of the fifth.

CENTRAL NERVOUS SYSTEM. Objective motor and sensory changes are frequently, but not invariably, present. The usual motor signs are wasting and loss of power, but occasionally there is fibrillation, and in rare instances complete paralysis. The muscles mainly affected are the triceps suræ and the flexors and extensors of the toes.

The chief sensory changes are cutaneous hyperalgesia and hypoæsthesia. Sometimes both are present, sensitivity being increased in some areas and reduced in others. The areas of altered sensation when accurately mapped are of assistance in determining the level of the protrusion (Fig. 57).



FIG 56 Myelogram The indentation on the left side of the column of pantopaque is made by a protrusion of the fifth lumbar intervertebral disc.

The tendon reflexes are often disturbed. The ankle jerk on the affected side may be diminished or absent; the knee jerks are usually brisk, and occasionally increased in the bad leg. The plantar responses are flexor.

LUMBAR PUNCTURE. The findings are positive only when there is a complete or nearly complete subarachnoid block. The Queckenstedt phenomenon is then positive, the protein content of the cerebrospinal fluid is increased, and it may be coloured yellow (Froin's syndrome).

RECTAL examination is necessary to exclude intra-pelvic causes of pressure on the sciatic nerve.

X-rays. Disc protrusions are not always accompanied by demonstrable X-ray changes, and although there may be narrowing of one or more intervertebral spaces, and also lipping of the bodies, similar changes are often found when there is no protrusion. Radiograp

however, essential to exclude disease of the vertebræ and to demonstrate the condition of the posterior intervertebral joints.

The routine investigation of sciatica formerly included myelography using a contrast medium (Fig. 56), but this procedure is no longer in general use. The findings are not entirely reliable; a negative myelogram is sometimes obtained when a protrusion is subsequently found at operation, and an apparently positive finding may be due to an artefact. Moreover, it is not always possible to remove the contrast medium completely and thus there is a danger that the residue will cause arachnoiditis. It is, however, of value in the differential diagnosis from tumours, and in some other circumstances, such as a recurrence of pain after a previous operation for a disc protrusion.

Nucleography, which involves the injection of a contrast medium into the nucleus (or the nuclear space) has been advocated. It might well be helpful but it entails a grave risk of damaging a normal annulus fibrosus.

Diagnosis

True sciatica is caused in all but an insignificant number of patients by mechanical interference with one or more nerve roots, and in at least 80 per cent it is due to intervertebral disc protrusion. The presence of a disc protrusion can safely be inferred when other disorders such as disease of the bodies of the vertebræ, spondylolisthesis and intra-pelvic tumours have been excluded. It is doubtful if osteoarthritis alone ever causes root pressure in the lumbar region, and thickening of the ligamentum flavum is no longer accepted as a cause of sciatic pain. Pain is not a prominent feature of primary neuritis or radiculitis. Disorders of the lumbosacral and sacroiliac joints may produce a posture rather similar to that in sciatica but the pain is not increased by dorsiflexion of the foot during straight leg raising, nor by coughing, and there are no organic sensory or motor changes. The pain in pseudo-sciatica is less severe than with true sciatica, and relief is given by infiltrating the "trigger point" with novocain.

Level of Lesion. The greatest number of disc protrusions occur at the fifth lumbar disc (i.e. that between the fifth lumbar vertebra and the sacrum), and there are nearly as many at the fourth lumbar disc, but only about 5 per cent are at the third lumbar. Double lesions in which there is protrusion of more than one disc, usually the fourth and fifth lumbar discs, are present in about 8 per cent of patients (Burns and Young). The affected root or roots are often indicated with some precision by the distribution of pain and the physical signs, but this does not give completely reliable information as to the level of the protrusion because a protrusion may be in contact with more than one root. The first sacral root crosses the fifth lumbar disc, and both fifth lumbar and first sacral roots cross the fourth lumbar disc. The first sacral root, therefore, may be in contact with a protrusion of either disc, and involvement of both roots may be due either to a protrusion of the fourth lumbar disc alone, or of both fourth and fifth lumbar discs.

When the *fifth lumbar root* is involved the pain passes down the back

of the calf to the heel and the sole of the foot; the sensory changes ar at the outer side of the thigh and knee, in front of the shin and on th inner part of the foot, and there may be weakness of dorsiflexion of the bi toe, and an absent or diminished posterior tibial reflex. The *first sacral roo* causes pain at the outer side of the calf and foot, and sensory changes in

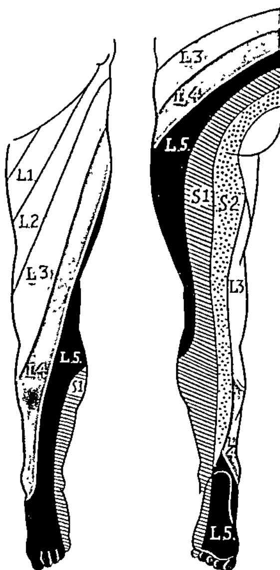


FIG 57. The dermatones of the leg (modified from Keegan)

the same area; there may be weakness of plantar flexion of the foot and the ankle jerk may be diminished or absent.

Radiological narrowing of an intervertebral space is some indication of the level of the affected disc, but protrusions do not always cause a significant amount of narrowing. Narrowing is often present when there are no symptoms attributable to disc protrusion, and sometimes a protrusion is found at operation at one level when the X-rays show narrowing at another.

Treatment

Fashions in the treatment of sciatica have fluctuated widely in recent years. It has long been known that there is a strong tendency to spontaneous recovery because for centuries it has been treated successfully by rest—the discovery that disc protrusions are a common cause cannot have altered the natural history of the complaint. However, the early successes with the operative removal of the protrusions resulted in the operation being performed with steadily increasing frequency until some surgeons came to regard operation as the proper sequel to a diagnosis of sciatica. At the same time the number of operative failures increased, whether because of the poor selection of cases or an indifferent surgical technique, and a conservative reaction has followed. At the present time operation is reserved for a strictly limited number of carefully selected patients.

The treatment of sciatica due to causes other than disc protrusions depends on the pathology and does not require separate discussion here.

The treatment of disc protrusions is conveniently divided into three categories: ambulant, bed and operative.

Ambulant. This may be tried when the pain is not too severe, especially in non-manual workers. There are two methods of approach, active and passive. Whichever is selected a regime should be instituted that *combines as much rest as possible with sufficient controlled* exercise to maintain the power of the spinal muscles. Advice should also be given about avoiding flexion strain (p. 74).

Active Treatment attempts to reduce the size of the protrusion by physical methods. The patient should attend for physiotherapy daily, or as often as is practicable, but a long and tiring journey by public transport must be avoided. Heat and massage are given to relieve muscle spasm, and then the spine is manipulated in rotation (p. 73). Manipulation should be gentle and the violent assaults sometimes made on the lumbar spine are to be deprecated. Sedatives must be given when they are necessary to ensure proper rest at night.

Manipulation under an anæsthetic is sometimes helpful and occasionally dramatic, but before it is carried out, the patient should be warned of the small risk that it will make him worse. The usual routine is follo[illegible] ime because it videns [illegible] sion to return. orcec [illegible] the protrusion. Success is more likely during a first attack than in subsequent ones when there has been time for the protrusion to become fixed by adhesions.

Traction may have an effect similar to manipulation and is intended to increase the size of the intervertebral spaces thus permitting a protrusion to return. The explanations so far offered as to why it is sometimes successful are not, however, acceptable for anatomical and physical reasons.

Epidural injection of a large volume of fluid is sometimes helpful, probably because it displaces the nerve root from contact with the protrusion. It is conveniently carried out whilst the patient is anæsthetized for

manipulation. The technique is simple but requires strict aseptic pre cautions. With the patient prone, two fingers of the left hand are placed on the cornua of the sacrum; a 15 cm. needle of large bore is introduced 2 cm. lower and directed cranially into the sacral canal. About 100 ccs of saline are then injected rapidly with as much pressure as possible.

PASSIVE TREATMENT is intended to prevent movement of the lumba *spine thus relieving pain, at any rate to some extent,* whilst the protrusio shrinks by the natural process of dehydration. It is indicated chiefly fo those patients who, for domestic or financial reasons, must do their utmo to continue at their work.

Immobilization is effected by means of a plaster corset or a surgic corset (p. 76). Since a surgical corset takes some time to make, a usu practice is to have the patient measured and then apply a plaster ca until the corset is ready. Immobilization should be continued, by night well as by day, until the pain has gone and the straight-leg raising test nearly normal; this may be a matter of weeks or months. Afterwards is usually desirable to continue to wear the corset by day only for sever months more, but physiotherapy, particularly extension exercises, shou be given to prevent the spine becoming stiff.

Bed. The routine treatment for the greater number of patien suffering from a severe attack of sciatica is rest in bed, and this usuall brings relief. The weight of the body is removed from the disc and th protrusion given the opportunity of shrinking. The mattress should b firm, if necessary with boards beneath it, and not more than two pillow are allowed. The patient must remain lying all the time, even when eatin and he is allowed out of bed only for defæcation because the strain of usin a bed pan may be greater than moving to a commode. Sedatives are give freely, specially during the first few days, and warmth is essential—a ho water bottle or an electric pad in the small of the back can be mo comforting.

This regime is continued for about three weeks, sometimes for a rath shorter or longer period. The patient is allowed to get up when the great part of the pain has gone and the treatment is continued as with ambula patients. If only a trivial amount of pain remains, treatment may be acti and physiotherapy is prescribed; but when there is rather more pain, plaster corset or surgical corset may be desirable.

Operation. The only absolute indication for operation, and this rare, is the sudden development of a partial paraplegia caused by pressu of a large protrusion on the cauda equina. The selection of other patien for operation is difficult because the indications are relative. It may b desirable when severe pain continues in spite of prolonged conservati treatment, or when there are frequently recurring attacks. The chi contra-indication is emotional instability with an excessive reaction pain because it is by no means certain that all the pain will be relieve

The results of operation vary with the care taken in selecting patient and with the technical skill of the surgeon. In the most favourable circum stances, it is doubtful if more than half, when judged by the stricte

standard, are entirely freed from all symptoms. The other half have some pain either in the back, or the leg or both; the pain is usually slight, and often transient, being felt only on exertion. About 85 to 90 per cent are able to return to full work and are highly pleased with the result; about 10 per cent are improved, but have a reduced capacity for work; in a small number, the protrusion recurs, either as the same or another level. There remain a few that are complete failures; they drift from surgeon to surgeon and are lucky if they escape multiple operations.

The operation consists in removal of the nucleus pulposus, the protruding annular portion of the disc, or both (Fig. 58). Many surgeons approach the disc between the laminæ and remove at most a nibble of bone, but some consider it advisable to have a wider exposure and perform

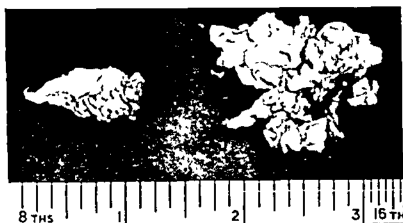


Fig 58 Disc protrusions removed at operation (cf Fig 54). Left—mainly annulus fibrosus Right—mainly nucleus pulposus.

a hemilaminectomy. The patient should remain in bed after operation for three weeks; graduated exercises are commenced after a few days and continued until there is full recovery. It is important to prevent too early a return to work, and to insist on full rehabilitation to the degree of fitness demanded by the occupation.

The original injury to the intervertebral disc, together with the loss of nuclear substance, must weaken the lumbar spine, and this is not helped by the operation. It must, therefore, be wise to avoid heavy work, and young people may be able to change their occupation without undue difficulty. With older patients, this is usually much harder and the advice should not be pressed because many men have managed to remain at the heaviest work and play every sort of game without further trouble.

Fusion of the fourth and fifth lumbar and the first sacral vertebræ at the same time as removal of the protrusion has been advocated as a routine procedure with the intention of making the back strong enough for heavy work. It has not, on the whole, been successful, perhaps because there is so often some degree of intervertebral disc degeneration at other levels and fusion increases the strain on these joints.

CHAPTER III

THE SPINE

THE INTERVERTEBRAL DISCS

Lesions of the intervertebral discs play a major part in the ætiology of a number of disorders notably sciatica, adolescent kyphosis, spondylosis and senile kyphosis. The clinical aspects of these conditions are discussed under their separate headings, but the pathological anatomy, which is still imperfectly understood, is more conveniently considered independently. The following simplified account is based on Beadle's and on Bradford and Spurling's monographs.

Anatomy

Vertebræ. The developing vertebræ grow in exactly the same way as long bones. The upper and lower surfaces of the vertebral bodies are each covered with a thin plate of hyaline cartilage which corresponds with an epiphysial disc and is responsible for growth in length of the vertebræ; the ossific centre is represented by a ring around the periphery of the cartilage plate. Ossification in the ring commences at a number of foci about the ninth to eleventh year, earlier in girls than in boys, and it fuses with the body about the twenty-second year. The entire cartilage plate does not, however, ossify, as is the case with other epiphyses, but only the ring; the central part of the plate, and also an extension to the posterior margin of the body where the ring is absent, remain cartilaginous throughout life.

The Intervertebral Discs develop from the primative mesenchyme around the notochord. The notochordal cells degenerate and become surrounded by a quantity of mucoid material which, in turn, is invaded by fine strands of fibrocartilage; the peripheral portion of the mesenchyme differentiates into the annulus fibrosus. The fully developed disc consists of two parts, the nucleus pulposus and the annulus fibrosus (Figs. 53 and 54, p. 82).

The Nucleus Pulposus is contained in an envelope of fibrocartilage which blends with the inner layers of the annulus. It is composed of mucoid material interlaced with fine fibres of fibrocartilage extending inwards from the envelope, and embedded in it are a few groups of cartilage cells and occasional degenerate notochordal elements. The nucleus is in contact above and below with the hyaline cartilage plates on the faces of the vertebræ, and it is confined peripherally by the annulus.

The Annulus Fibrosus consists of densely interwoven bundles of connective tissue amongst which are some elastic fibres and some areas of

fibrocartilage. The outer laminæ are more clearly differentiated than the inner; the inner laminæ decrease in connective tissue and increase in fibrocartilage content as the centre of the disc is approached until they finally merge with the containing envelope of the nucleus. Fibres of the annulus are attached to the bony epiphysial ring and to the cartilage plates thus binding the vertebræ together.

The nucleus is under tension and bulges when the annulus is incised. Bradford and Spurling consider the tension is due to pressure of the elastic fibres of the annulus and not, as is often stated, to an expansile force within the nucleus. In fact the nucleus is squeezed through a defect in the annulus just as a piece of soap from a wet hand. The nucleus obeys the laws of fluids and this enables it to fulfil its principal function of distributing stresses evenly over the whole of the opposing surfaces of the body of each vertebra. This happens regardless of the shape of the vertebræ and the position of the spine. Another function is to act as a shock-absorber when a sudden force is applied; the stresses to which it is subjected are considerable and in some circumstances may be equivalent to a ton weight.

Ligaments. The anterior longitudinal ligament is a broad band covering the anterior surface of the vertebræ from the occiput to the sacrum. It is firmly attached both to the bodies of the vertebræ and to the intervertebral discs.

The posterior longitudinal ligament extends from the axis to the sacrum and lies within the neural canal. It is denticulate in shape, being rather broader opposite the intervertebral discs with which it is intimately blended. It does not, however, cover the whole of the posterior aspect of the discs and most disc protrusions are lateral to it.

The ligamenta flava join the laminæ of the vertebræ together. They extend laterally beneath the posterior intervertebral joints and project into the posterior and inferior aspects of the neural foramina. They vary considerably in thickness but it is not now thought that a hypertrophied ligament alone can cause symptoms by pressing on a nerve root.

Pathology

The factors causing pathological changes in the intervertebral discs are not fully understood. The following is a simplified account of present knowledge of the processes concerned, but they are not always as distinct as it suggests.

(a) Injury to the hyaline cartilage plates—
adolescents — Schmorl's nodes
adults — Kummell's disease

(b) Injury to the annulus fibrosus—
adults — intervertebral disc protrusion

(c) Dehydration of the nucleus pulposus—
adolescents — adolescent kyphosis
adults — spondylosis
senile kyphosis

Hyaline Cartilage Plates. Injuries to the hyaline cartilage plates occur chiefly during adolescence and less frequently in adults.

ADOLESCENTS. The way in which the plates are damaged is not known for certain but it is thought that flexion injuries, either a single major injury or repeated minor ones, may play a part. Lambrinudi has drawn attention to the frequency with which adolescent kyphosis and short hamstrings are associated, and he suggests that repeated forced attempts to touch the toes during "gym" and similar activities may sometimes cause damage. It is known that the relative length of the hamstrings decreases from infancy until early adolescence and then, in most people, increases again.

When a cartilage plate has been injured, the nucleus pulposus is able to permeate through the resulting crack into the spongy bone of the vertebra. The bone reacts by forming first a shell of hyaline cartilage over the prolapsed tissue, and later a layer of compact bone around the cartilage (Fig. 59B). The resulting cup-shaped depressions in the vertebral bodies, known as *Schmorl's nodes*, are often seen in adolescent kyphosis.

ADULTS. It has long been observed that occasionally, after trauma, one vertebra slowly becomes wedge-shaped (*Kümmel's disease*). There is no radiological evidence of injury to bone immediately after the accident and the process of compression is gradual. A possible explanation is that the hyaline cartilage plate is fractured at the time of injury and this permits extrusion of the nucleus into the substance of the bone causing trabecular absorption and collapse. It appears that adult bone does not react in the same way as adolescent bone and the protrusion is not walled off.

Annulus Fibrosus. Injury to the annular portion of the disc is thought to occur chiefly during adolescence and early adult life, probably as the result of flexion violence. Symptoms do not necessarily follow immediately, but sooner or later, possibly after years, an additional strain may cause the nucleus to extrude through the annulus, or else cause the damaged portion of the annulus itself to prolapse (Fig. 59C). Such protrusions impinging on the spinal nerve roots, when occurring in the lumbar spine, are the commonest cause of *sciatica;* in the thoracic region, they can cause pain referred to the abdomen and simulating visceral disease, whilst in the neck they are a frequent cause of pain in the arm and hand.

Dehydration of the Nucleus Pulposus. Many workers have investigated the natural changes that take place with increasing age. It seems that invasion of the nucleus by fibrocartilage, which commences at an early stage in fœtal development, normally continues throughout life. By the fourth decade it has advanced sufficiently to reduce the elasticity; by the fifth, the cellular elements begin to disappear, and finally the nucleus becomes an amorphous, pigmented mass. At the same time the water content of the nucleus becomes progressively less and the disc is correspondingly less able to fulfil its function of distributing stresses evenly over the bodies of the vertebræ. Dehydration also occurs when there is a protrusion of the nucleus through a defect in one of the hyaline cartilage plates or the annulus fibrosus.

The buffering action of the nucleus may be red[illegible] en duri[illegible]

adolescence, and some change is universal by middle age. Degenerative changes of the type usually associated with old age therefore begin earlier in the spine than elsewhere in the body. As the intervertebral discs become less resilient, the stresses on the adjoining vertebral bodies are increased, the anterior portions of the bodies being affected more than the posterior because the latter are protected by the support of the neural arch and intervertebral joints.

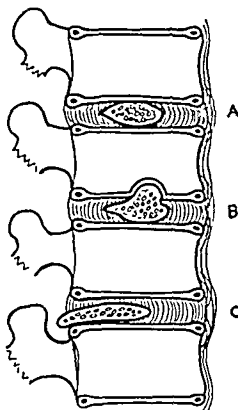


Fig. 59 Intervertebral discs.
A Normal
B Schmorl's node
C. Posterior nuclear protrusion

The reaction of the vertebræ to increased and ill-distributed pressure varies with the condition of the bone at the time :—

Adolescents. Development is not complete and increased pressure on the front of the bodies retards growth and causes them to become wedge-shaped. This is a typical feature of *adolescent kyphosis* (p. 97). Disturbance in the regular ossification of the epiphysial ring can be seen radiologically ; it appears fragmented, specially the anterior part, and sometimes ossification is suppressed causing a distinct notch in the anterior corner of the body. This condition was described by Scheuermann, with whose name it is associated, but he regarded it as a form of osteochondritis juvenilis.

Adults. The intervertebral discs are firmly attached to the bodies of the adjoining vertebræ and form an important bond between them. Reduction in the efficiency of the discs increases the stresses on the vertebræ, particularly at the anterior and lateral parts of the periphery,

and the reaction is new bone formation. The resulting spurs, lips and beaks are evidence of disc degeneration (Fig. 60). These changes do not necessarily cause symptoms, and they must not be confused with osteoarthritis, a condition affecting the diarthrodial, posterior intervertebral joints (p. 68).

THE ELDERLY. When the bodies of the vertebræ are somewhat porotic, as is not uncommon, the increased pressure causes them to absorb anteriorly

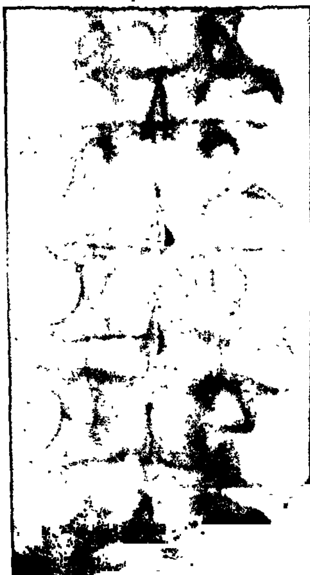


FIG 60 Lipping of the bodies of the vertebræ This is evidence of intervertebral disc degeneration (spondylosis) and *not* of osteoarthritis

and become wedge-shaped (*senile kyphosis*, p. 99). It is possible that the hyaline cartilage plates also fissure allowing the nucleus pulposus to penetrate the spongy bone and cause trabecular absorption. The discs sometimes ossify, especially anteriorly, thus fusing the front of the bodies together.

This condition is in marked contrast to that in which the vertebræ are atrophic but the intervertebral discs are healthy and the cartilage plates intact. The discs then expand without destroying the intimate structure of the bone (*senile osteoporosis*, p. 100).

ADOLESCENT KYPHOSIS

This is a common condition of which the outstanding feature is the gradual development of thoracic or thoraco-lumbar kyphosis. It is caused by the pathological changes in the vertebræ and the intervertebral discs which, as described in the preceding section, cause the vertebræ to become wedge-shaped.

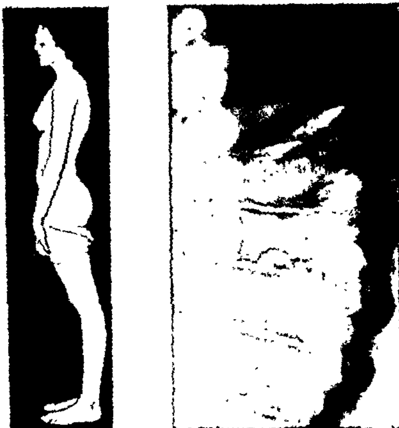


Fig 61 Adolescent kyphosis in a girl aged 17 who had no pain There is wedging of the vertebræ, the intervertebral spaces are narrow, and small Schmorl's nodes are visible

Clinical Features

The onset is during adolescence, but the deformity persists throughout life and it was observed in nearly 2 per cent of some 500 "normal" young adults examined by the author. The condition is usually said to occur with greater frequency in males than females because they are more exposed to trauma, but Burns and Ellis found females to preponderate in the proportion of two to one in a large series.

The deformity commences at twelve to fifteen years of age, often before there is any pain, and frequently it is first discovered during a routine physical examination. The kyphos involves the middle and lower thoracic regions; the curve is smooth and is accentuated during flexion because it interrupts the even line of the rest of the back. The lumbar and cervical curves are increased in compensation (Fig. 61).

Pain tends to start rather later than deformity. It may be complained of by boys after they first begin working, hence the disease is sometimes

known as "apprentice's kyphosis". During the active stage pain is felt the region of maximum deformity; it is not severe and usually comes towards the end of the day, or after playing games.

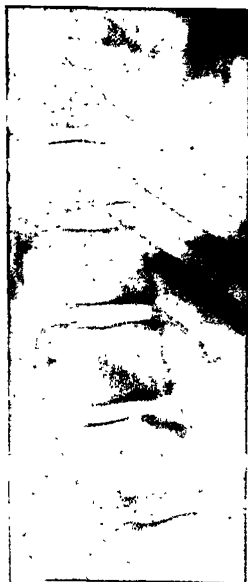


Fig 62 Adolescent kyphosis in a girl [illegible] thoracic vertebra might be mistaken for tuberculosis

In the absence of treatme deformity may progress until ossific tion is complete at about twenty-t years of age, and thereafter it is pen anent. The appearance is characteris and can be recognized at any age. Pa ceases with growth but it often rec in later life, usually in the lumbar regi where there is a compensatory lordos

Thoracolumbar Kyphosis. Tl deformity is associated with certa postural defects, and although it very common in girls, it is often ov looked (p. 9). The pathology a X-ray appearances are identical wi the more generally recognized form adolescent kyphosis described abov the course also is similar but pain usually less marked.

X-rays. (Figs. 61 and 62.) T principal features are irregularity ossification of the epiphysial ring Schmorl's nodes and wedging of t vertebræ (p. 94). There is often sor narrowing of the intervertebral spac The differential diagnosis from tub culosis is occasionally difficult but the is no general rarefaction of bone abscess formation, and the outli of the bodies of the vertebræ is inta except at the angles.

Treatment

The object of treatment is to r duce the pressure on the front of th vertebræ thus giving them a bett opportunity to grow. This cannot b done by any form of support worn whilst the patient is up and abou and a plaster bed is necessary. When there is pain, or when the deformit is severe, he should lie on the bed both by day and night, preferably hospital; with milder cases, it may be sufficient just to sleep on it at nigh

The plaster bed is made in the position of greatest correction bu without exaggerating the lumbar curve. The hollow in the bed corr sponding to the kyphosis is gradually filled with padding over a perio

of a month thus extending the thoracic spine and reducing the pressure on the front of the bodies. When the bed is used by day and night, the patient is allowed up for toilet purposes and for remedial exercises; exercises should not be very strenuous because they are only intended to preserve general muscle tone and are not actively corrective. This regime is continued until no further correction can be obtained and there is freedom from pain, usually six to twelve months, but a plaster bed should be used at night for a longer period because there is no better way of increasing a kyphos than by lying on an ordinary bed.



Fig 63 Senile kyphosis The intervertebral spaces are narrow anteriorly and the bodies are beginning to fuse.

SENILE KYPHOSIS

This condition is characterized by curvature affecting the upper thoracic vertebræ and is usually associated with a greater or lesser degree of osteoarthritis of the corresponding intervertebral joints. It occurs particularly in manual workers and seldom before sixty years of age although occasionally it is seen much younger. The process starts in the intervertebral discs which undergo degenerative changes of senile type (p. 94); the discs become thinner, specially anteriorly, their resiliance is reduced and the pressure on the front of the vertebral bodies is increased. The vertebræ, possibly already porotic, absorb anteriorly becoming wedge-shaped and finally the discs ossify thus fusing together the anterior borders of vertebræ (Fig. 63).

The symptons are pain and deformity. Pain occurs during the active stage ; it is often severe and usually is worse at night when it may interfere with sleep. After the active phase is complete and the vertebræ have fused, pain in the region of the kyphos disappears. There may, however, be pain in other parts of the spine due to spondylosis or osteoarthritis.

Deformity affects chiefly the upper thoracic vertebræ; it is of characteristic appearance and tends to increase until fusion is complete when it becomes stationary. The deformity, if severe, is disabling, and the whole spine may become so stiff that compensatory curves cannot be developed and it is difficult to stand upright.

There is no satisfactory treatment. A plaster bed for use at night relieves pain and reduces the rate of increase of deformity, but not all elderly patients can accustom themselves to sleeping in one. A high surgical corset with shoulder straps may be worn during the day (p. 76).

SENILE OSTEOPOROSIS

Middle-aged or elderly people (they are seldom senile !) sometimes suffer from a condition in which there is an osteoporosis of the bodies of the vertebræ without, as a rule, a generalized osteoporosis of the whole skeleton. Not infrequently the porosis is of such remarkable degree that the vertebræ collapse either spontaneously or as the result of very minor injury. A single body, or more often two or three adjacent ones, give way anteriorly and are reduced to a fraction of their original thickness ; occasionally several groups of vertebræ in different parts of the spine may collapse. The intervertebral discs remain intact, and since they are not as a rule degenerate, their elasticity causes them to bulge out into the soft bones giving the appearance of bi-convex lenses (Fig. 64).

The metabolic significance is not known. Elaborate biochemical investigations have been carried out by many workers without any constant findings. Since the condition occurs usually in women, and nearly always after the climateric, several of the endocrines have been incriminated, but without any real justification. The name "post-climateric osteoporosis", which is sometimes used, may be an accurate statement of fact, but it suggests an etiology that has not been substantiated.

The principal complaint is pain, and even before there is any vertebral collapse, advice may be sought because of persistent backache. There is no characteristic feature and the diagnosis is made radiologically. Collapse occurs without any gross trauma and most patients are unaware that it has happened. Minor degrees of collapse may not cause additional symptoms, but extreme collapse may cause pressure on the nerve roots in the intervertebral foramina and give rise to most intractible pain of root distribution; spasms of pain are brought on by any movement of the back, particularly rotation, and sleep is difficult because spasms occur as soon as the muscles relax.

Treatment. The course of the complaint is variable and unpredictable; sometimes there is spontaneous arrest at an early stage, but there may be steady deterioration. No treatment is known that will either

arrest progress or effect recalcification. Relief from pain, at any rate in the early stages, sometimes appears to be given by the administration of sex hormones, either stilbœstrol or testosterone regardless of the sex of the patient. Stilbœstrol is perhaps safer because it has fewer side effects. A very small dosage is used, say mgms 0·5 twice daily, continued for months.

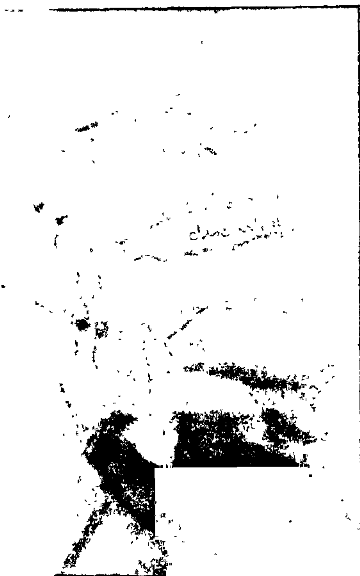


Fig 64 Senile osteoporosis with marked collapse of the lumbar vertebræ The patient had severe pain in the distribution of the fourth lumbar nerve root

A spinal support is desirable when the porosis is marked in order to reduce the risk of vertebral collapse, and after collapse has occurred, it helps to relieve the pain. Many patients, being rather frail, are unable to wear a rigid brace and at most can tolerate a surgical corset (p. 76). A plaster bed is of value when pain at night is severe ; it is not tolerated in other circumstances. Severe root pain is not always controlled by opiates and can be so distressing as to demand drastic measures ; a localized intrathecal injection of alcohol may be practicable but sometimes there is no alternative to division of the pain tracts in the spinal cord.

ANKYLOSING SPONDYLITIS

(*Synonym*) Spondylitis Ankylopoietica

This common disease is characterized by ossification of the joints and ligaments of the spine. It may be allied to rheumatoid arthritis although little is known about the ætiology. The incidence is greatest during the third and fourth decades and males are affected eight or nine times more often than females. The disease occurs in a common form and in two special types



FIG 65 Ankylosing spondylitis Oblique view showing ossification of the intervertebral joints

but it is probable that all three types represent different reactions to the same disease process. The special types are uncommon in pure form but any of their features may be seen complicating the ordinary form.

Pathology

JOINTS. The sacroiliac joints are usually the first to be affected, then the intervertebral joints are involved, and often the manubrio-sternal and the costo-vertebral joints. Some of the general features of rheumatoid arthritis are present—atrophy, infiltration and thickening of periarticular tissues, and destruction of articular cartilage—but the characteristic

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spine almost invariably ossify (Fig. 66), and less frequently the ligamentum flavum and interspinous ligaments are involved. The intervertebral discs do not become ossified (except in the rare Bechterew's type); indeed, the normal radiological appearance of the discs is a diagnostic feature.



Fig 66 Ankylosing spondylitis with extensive ossification of the lateral longitudinal ligaments ("bamboo spine")

Bone. The structure of the bodies of the vertebræ is not greatly altered, but the bone adjacent to the sacroiliac joints is usually porotic at a very early stage, and later sclerotic.

Muscles. Wasting of the skeletal muscles is occasionally very marked and is much greater than can be attributed to disuse alone. It appears to be part of the disease and is perhaps caused by chronic inflammation of the spinal dura and degenerative changes in the posterior root ganglia and posterior columns of the cord (Strümpell).

Strumpell-Marie Type (*Spondyloserhysomyelique*). In this typ the "root" joints are also affected. The process begins at the hip, sacroilia and lower lumbar joints and spreads slowly up the spine; in an extrem instance the shoulders and sterno-clavicular joints are ultimately involved Examples have been described in which the knees and elbows are affecte but, as a rule, the failure of these and the smaller joints of the hands an feet to participate is striking. If the hips are allowed to ankylose in flexior as happens if the patient is put to bed without special precautions, dreadful deformity results; the kyphotic spine is unable to compensat for flexion of the hips and the trunk is parallel with the ground when th patient tries to stand.



Fig 59
Ankylosing spondylitis

Bechterew's Type. The distinguishin feature of this rare form is ossification of th intervertebral discs which are converted int bone of the same consistence as the bodies of th vertebræ. The longitudinal ligaments and th intervertebral joints also ossify and the spina column is converted into a hollow tube with th spinal cord in the centre.

Clinical Features

The typical patient is a man in the twentie usually of spare build, complaining of a constan ache in the low back; when he is asked to benc the lumbar spine remains rigid but the pain is no greatly increased. This picture is so characteristi as to be almost diagnostic, but it is not always s well defined. The patient may be a woman; th age at onset may be younger or older; the pai may be more severe, or it may be quite trivial an deformity the first complaint. The history ma be short and progress rapid, or there may be man years of minor discomfort before advice is sough

The erythrocyte sedimentation rate is alwa raised during the active phase. Although it usuall falls gradually as the disease becomes quiescent, it may take a long time t return to normal and therefore it is not a reliable indication of progress. I may remain permanently high in severe cases with periodic exacerbation

The outstanding features are pain, stiffness and deformity.

Pain starts insidiously in the low back; at first it may be inte mittent but it progresses slowly until it becomes constant. Most patient are still at work when they first come under observation; they are not il and have little deformity, but they complain of pain. It is made worse b exertion and does not disappear entirely with rest. Not infrequently th pain radiates into the buttocks and thighs, and sometimes there is girdl pain of abdominal or thoracic distribution. Occasionally it starts in th thoracic or cervical spine.

Stiffness is due at first to muscle spasm and later to ossification of the ligaments and joints. The lumbar spine is nearly always rigid from the beginning even though there are no radiological changes. In severe cases the rigidity spreads upwards to involve the thoracic and even the cervical spine. The costovertebral joints are often affected and then movements of the thorax ceases, or is greatly reduced, and thoracic respiration is diminished accordingly. The hips and shoulders, and occasionally the knees, elbows and feet, become ankylosed in the Strümpell-Marie type.



Fig 68. Early ankylosing spondylitis with involvement of the sacroiliac joints, but not the lumbar spine The joint surfaces are irregular and there is sclerosis of the adjacent iliac bone

Deformity, when present, is characteristic. The head is bent forwards, the thoracic curve is increased and the lumbar curve is obliterated (Fig. 67). When the hips are involved they often become fixed in a flexed position and the body leans so far forwards that it is impossible to balance without the aid of sticks. In extreme cases the trunk is nearly parallel with the ground and it is impossible to see more than a few feet ahead.

X-Rays. The first changes occur at and around the sacroiliac joints; usually both joints are involved, but sometimes only one. The joint surfaces appear fluffy and irregular in outline and the adjacent iliac bone becomes porotic. Later on the porosis is replaced by sclerosis (Fig. 68), the joint space becomes narrower and finally it disappears entirely. The manubrio-sternal joint often shows similar changes at a comparatively early stage.

Ossification in the longitudinal ligaments is more easily seen in lateral than in antero-posterior views, but in time all the paravertebral ligaments are ossified. The intervertebral joints are gradually obliterated, commencing as a rule in the lumbar region and spreading gradually upwards. The intervertebral discs are involved only in Bechterew's type, and in the other varieties the remarkable way in which the disc spaces keep their usual size is one of the diagnostic features. On the other hand the symphysis pubis is liable to be obliterated in all types of the disease.

Course. This is so variable that it is impossible, unless there is a long history, to give a prognosis until after a period of observation. In a large number of patients, in the absence of treatment, there is slow progress for a number of years until all the lumbar, and perhaps also the lower thoracic joints are ossified, and then the disease seems to burn itself out. Sometimes there is spontaneous arrest with only the sacroiliac joints implicated, but with other patients progress is much quicker and the entire spine and the proximal joints of the limbs are all involved within a few months. As a rule there is no recurrence after arrest, but there may be recurring exacerbations at intervals of a few years. The disease is not fatal but respiratory complications are common when thoracic movements are greatly reduced.

Treatment

Radiotherapy. Modern developments in radiotherapeutic technique have transformed the prognosis, and although inadequate dosage is next to useless, with proper management it is possible to arrest progress and often to restore some movement to stiffening joints. Bony ankylosis cannot, of course, be affected.

Professor B. W. Windeyer has treated more than 1500 patients giving an incident dose of 1500 *r* to 2000 *r* to each field during a period of a month. Treatment was most effective when commenced early and the disease was limited to the sacroiliac joints and the longitudinal ligaments of the lumbar region. In these circumstances he succeeded in arresting progress in almost all, and 90 per cent have remained free from recurrence for a number of years. When involvement was more extensive, the percentage of recurrences was rather higher, but they occurred chiefly at joints previously unaffected. Even with advanced disease, it was usually possible to relieve pain and muscle spasm, and often to arrest progress at the areas treated.

Physiotherapy. Active exercises designed to maintain the greatest range of movements at affected joints should be begun as soon as the diagnosis has been made and continued as long as the disease remains active. Particular attention must be paid to retaining the movements of the chest.

Operation. When both hips are ankylosed, it is sometimes possible to restore a useful range of movements by arthroplasty, but this should not be attempted until the disease is quiescent. Forward bowing of the spine can be corrected by osteotomy of the lumbar spine and it is greatly appreciated by patients with the most severe grade of deformity.

STRUCTURAL SCOLIOSIS

It is customary to divide scoliosis into two main groups, postural and structural, but the ætiology, pathology and treatment differ so widely that they cannot be regarded as the same disease. Postural scoliosis is a defect of minor importance which can be corrected by voluntary muscular effort, and it is not associated with changes in the shape of the vertebræ; it is a disorder in function and as such is properly included with the other postural defects (p. 14).

Structural scoliosis is a deformity in which there is lateral curvature of the spine combined with rotation of the vertebræ; the shape of the vertebræ is altered and correction by voluntary effort is impossible. It might be expected to pass through an early stage in which it is fully correctible, but whilst this may be so in theory, in practice the transition from a mobile to a structural curve is seldom, if ever, observed.

Ætiology

There is a formidable list of possible causes of structural scoliosis which is given in abbreviated form below. The majority of cases are due to muscular failure and this is the only type that will be discussed in detail.

A. Congenital.

B. Acquired.

1. *Diseases of Bone:*
   - (*a*) Rickets.
   - (*b*) Tuberculosis and other destructive diseases.
2. *Compensatory to obliquity of the Pelvis:*
   - (*a*) Real or apparent shortening of one leg.
   - (*b*) Deformity of the hip.
3. *Compensatory to Torticollis.*
4. *Muscular Failure.*
   - (*a*) Anterior poliomyelitis.
   - (*b*) Of unknown origin (idiopathic).

Congenital Scoliosis. There is faulty ossification of one or more vertebræ causing gross deformity. The salient feature in the usual type is failure of development of one half of the body (*hemivertebra*), but there are usually other defects as well, including irregularity in the arrangement of the ribs. The picture is very complex when a number of defects occur simultaneously (Fig. 69). The deformity of necessity increases with growth of the hemivertebræ and may become extreme.

Treatment is of little avail. Spinal fusion by means of a graft placed on the convex side of the curve, if carried out at an early age, may restrict growth of that side to some extent.

Diseases of Bone. Rickets is now a rare cause of scoliosis in western countries although once it was common. Tuberculosis, which is the only common destructive disease of the spine in children, causes kyphosis more often than lateral curvature, and in the few instances in which there is scoliosis the element of rotation is absent.

Compensatory Scoliosis. When the pelvis is oblique, the spine is curved in the endeavour to assume an erect position (Fig. 70). The common cause of obliquity of the pelvis is real or apparent shortening of one leg; shortening up to half an inch has little visible effect on the spine, but more than that produces a distinct compensatory curve. Congenital asymmetry of the pelvis is very occasionally severe enough to cause compensatory



FIG 69 Multiple congenital deformities of the vertebræ and ribs

scoliosis, but it must be distinguished from the more usual case in which pelvic asymmetry is the result of scoliosis, not the cause.

Severe compensatory scoliosis present from an early age causes minor structural changes in the vertebræ but the curve always remains partly correctible. It is, for example, corrected by sitting because the pelvis is then level and there is no longer any need for compensation; the force causing the scoliosis only acts part of the time, i.e. when standing or walking, and therefore there is less tendency for the deformity to become fixed, and it does not become progressively worse.

TREATMENT is unnecessary unless the difference in the length of the legs is more than a third of an inch, indeed it is unwise to tell the patient when this amount is discovered during routine examination. When the difference is half an inch or more the heels of the shoes are altered, one heel

being raised and the other lowered by half the required correction. Full correction is not necessary; thus with a disparity of one inch it is sufficient to raise one heel a quarter of an inch and lower the other an equal amount. The sole need not be raised unless the heel has been lifted at least one inch. With some patients it may be preferable to lengthen one leg or shorten the other by operation.



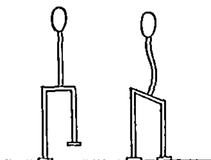


Fig 70 A girl of 16 with 2½ inches of shortening of the right lower limb

Torticollis. Upper dorsal scoliosis associated with untreated sternomastoid torticollis should never be allowed to develop, but severe deformities are still seen occasionally.

Muscular Failure. This is the usual cause of severe scoliosis.

There may be a known cause of paralysis, such as anterior poliomyelitis, or the origin may be unknown when it is termed idiopathic.

ANTERIOR POLIOMYELITIS accounts for a fair percentage of cases which varies from country to country according to the incidence of this infection. Scoliosis occurs when there is unilateral paralysis, or greater paralysis of the muscles on one side of the spine than the other. The curve is concave towards the *stronger side, and it is rapidly progressive during the growth* period. Paralysis of the abdominal muscles may cause lateral curvature even when the spinal muscles are unaffected.

Treatment follows the same general lines as with "idiopathic" scoliosis. There is, however, a stronger tendency for the curve to become severe and the back must be supported from the very start. Spinal fusion is often desirable at an early stage.

"Idiopathic" Scoliosis

This is the commonest type of severe scoliosis but next to nothing is known about the ætiology. It has been suggested that the primary defect may be lack of proper co-ordination of the small rotator muscles controlling the movements of individual vertebræ, but this can hardly be the cause of the infantile form.

Nomenclature. The deformity consists in a main curve with compensatory curves above and below to make the trunk more or less vertical. Sometimes there are two main curves in opposite directions joined to form an S. The curves are named after the region affected by the main curve and the direction of its convexity. The regions are designated as lumbar, thoracolumbar and thoracic. A curve in the thoracolumbar region with its convexity to the right is referred to as a right thoracolumbar scoliosis. When there are two main curves, say right thoracic and left lumbar, the condition is described as a combined right thoracic, left lumbar scoliosis.

The amount of curvature must be recorded accurately in order that any increase can be detected quickly and the effect of treatment assessed. There are several methods of measurement, all by means of radiographs made with the patient standing (Fig. 71). One method is to draw two lines from the centre of the body of the vertebra at the apex of the curve to the centres of the bodies at each end. The angle between these lines subtracted from 180° is the amount of deviation from the straight. Cobb's method is to measure the angle between perpendiculars drawn from the upper and lower surfaces of the bodies of the vertebræ at each end of the main curve. These vertebræ can be recognized by the shape of the intervertebral spaces. The spaces are wedged so as to be wider on the convex side, but at the extremities of the main curve they are either of equal width or wider on the concave side.

Mechanics. Much ingenuity has been devoted to explaining the exact mode of development of lateral curvature, but no theory is entirely satisfactory and none is universally accepted. For practical purposes the spine can be regarded as "buckling" in a region in which there is a disorder in muscular function. If the disorder is limited to a small area in the thoracic or lumbar region, there is a thoracic or a lumbar scoliosis with a smaller, secondary, compensatory curve below or above the primary curve. The more severe combined curves occur when there is extensive muscle failure which involves both thoracic and lumbar regions.

Lateral deviation is always accompanied by rotation; one cannot occur without the other, but their relative severity varies and sometimes one and sometimes the other predominates. When a curved rod is given a second curve in a different plane, it necessarily twists in its longitudinal axis. The spine is such a rod curved in the antero-posterior plane, and when a lateral curve is superimposed, torsion stresses are set up and the vertebræ rotate. The rotation is in that direction which moves the bodies of the vertebræ towards the convexity of the curve and the spinous pro-

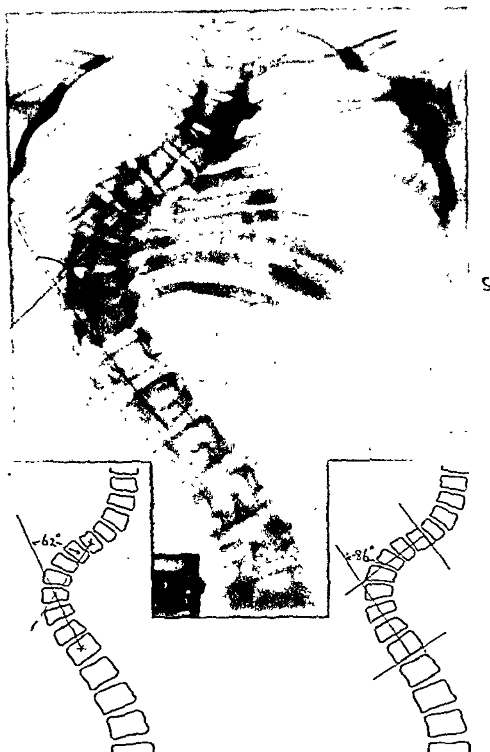


FIG 71 "Idiopathic" left thoracic scoliosis

The top vertebra of the primary curve is that with the disc below it broader on the convex side, and the disc above broader on the opposite side; the bottom vertebra has the disc above it broader on the convex side, and the disc below broader on the opposite side.

Left The amount of curvature is often measured by joining the centre of the body of the vertebra at the apex of the curve with the centres of the bodies at each end.

Right · Cobb's method of measurement is to determine the angle between the perpendiculars drawn from the top and bottom of the vertebræ at the extremities of the curve.

cesses towards the concavity, i.e. the bodies are displaced further from the mid-line than the spines. A kyphotic element is often superimposed on the lateral curve, particularly when the primary curve is thoracic.

Changes in the shape of the vertebræ take place whilst they are still growing in response to alterations in pressure and in adaptation to the abnormal posture. The bodies are compressed on one side, the exact shape varying with the position in the curve; that at the apex is wedged but the others tend to be lozenge shaped (Fig. 71). The pedicles, articular processes and transverse processes are mis-shapen and the neural canal becomes triangular in cross section. The thorax is often seriously distorted in thoracic scoliosis but the extent depends on the degree of rotation. The ribs rotate with the vertebræ and project forwards on the side of the concavity, and backwards on the side of the convexity. Sometimes the posterior angles of the ribs are bent so sharply that the resulting deformity is well described as "razor back" (Fig. 72).

Clinical Features. Two main groups are distinguished according to the age at onset—infantile and adolescent.

INFANTILE idiopathic scoliosis is not very uncommon having been found by J. I. P. James* in about ten per cent of patients seen at his scoliosis clinic. It differs from adolescent scoliosis in that it occurs more often in boys than girls and the curve is usually convex to the left. It affects almost exclusively the middle or lower thoracic regions. The curvature is usually noticed during the first year of life, and as a rule there is slow but steady progress until, by adolescence, the deformity is very severe.

ADOLESCENT idiopathic scoliosis is the common form of this complaint. Girls are affected about nine times more frequently than boys, and the convexity of the curve is usually to the right. The deformity is generally noticed for the first time between ten and fifteen years of age, most often at eleven or twelve. Occasionally it starts as young as five years, but this is uncommon. Thoracic curves are usually seen at a younger age than lumbar or combined curves, perhaps because they are more obvious. The curvature may be discovered at a routine school examination, or the child is brought to the doctor because the parents or dressmaker have noticed that one hip sticks out, or that one shoulder is high (Fig. 73).

The presence of scoliosis is easily diagnosed on clinical examination provided it is carried out with the child completely undressed. A small curve is made more obvious by flexing the spine fully. The differential diagnosis from postural lateral curvature depends on the fixity of the curve which is not corrected by standing on one leg, by sitting or by flexing the spine. Structural scoliosis other than "idiopathic" is readily identified by the presence of clinical or radiological evidence of the causative disease, but it may be difficult to recognize scoliosis due to anterior poliomyelitis with residual paralysis restricted to the smaller muscles of the spine.

Symptoms, other than deformity, are most unusual during adolescence or early adult life. Indeed, it is striking how little interference there is with function even when the curvature is moderately severe, provided supple-

*J. I. P James, *Journal of Bone and Joint Surgery*, 1951, 33B, 399



Fig 72 Severe thoracic Scoliosis with gross rotation of the vertebræ causing a "razor back" deformity



Fig 73 Left thoracolumbar scoliosis.



Fig 74 Combined left thoracic right lumbar scoliosis

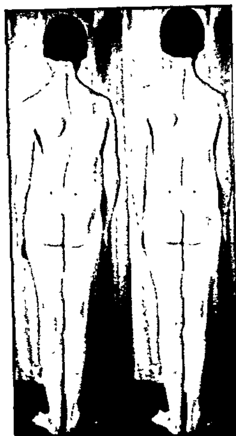


Fig 75 Mild thoracic scoliosis treated by remedial exercises with marked improvement in posture Note the apparent increase in height.

ness is maintained. The girl illustrated in Fig. 74 is an excellent tenni player, and there are several athletes and ballet dancers with a marke scoliosis. Very severe deformities may give rise to symptoms throug mechanical interference with thoracic or abdominal viscera, and ver occasionally gross distortion of the spinal canal causes a partial or complet paraplegia by compression of the cord.

Pain is unusual before middle age but the muscles of the back ar working at so great a mechanical disadvantage that they are unable t stand up to the strain indefinitely and sooner or later this gives rise t backache which may be very distressing. The pain is greatest at the level where the curves change direction, that is at the apex, at the transition of combined curve from one side to the other, and the transition of main to a compensatory curve. The most useful treatment is to provide spinal support, and fortunately this usually gives considerable relief.

Prognosis. It is imperative to have as accurate an assessment as i possible of the prognosis of each patient before deciding on treatment Attempts at correction may otherwise be left until it is too late, and conversely many spinal fusions will be performed unnecessarily.

The prognosis depends to a considerable extent on the age at onset and on the level of the curvature, or what is now called the "curve pattern". Ponseti and Friedman* studied the end results in a large series of carefully documented patients treated conservatively in Steindler's clinic and established that there are four curve patterns—lumbar, thoracolumbar, combined thoracic and lumbar, and thoracic—each with a characteristic behaviour. They found also that the earlier the age at onset, the greater was the probability of the deformity increasing.

A generalization of the position is that the higher the level of the main curve and the earlier the onset, the worse is the prognosis. The reverse also holds; lumbar scoliosis is seldom very serious, and scoliosis developing after fourteen years of age does not often progress. There are individual exceptions to the general rule but they can usually be recognized after a few months of observation.

LUMBAR curves have their apex at the first or second lumbar vertebra. They account for about one quarter of all cases and are the most benign. They start comparatively late and do not often increase to more than 40°. There is no interference with function, and compensation is so good that not infrequently they remain unrecognized until they begin to cause pain during middle age or later.

THORACOLUMBAR curves are the least common and have their apex at the eleventh or twelfth thoracic vertebra (Fig. 73). They tend to start late, and although the curves often become rather greater than in the lumbar region, compensation is good and there is little interference with function. They are, however, more easily visible and more often give rise to cosmetic complaints.

COMBINED THORACIC AND LUMBAR curves are the most common type of all (Fig. 74). The apex of the upper curve is usually at about the seventh

*I. V. Ponseti and B. Friedman, *Journal of Bone and Joint Surgery* ... 32A 381.

or eighth thoracic vertebra, and the apex of the lower, at the second lumbar. They usually start a little earlier and progress rather further than single thoracolumbar curves, but since they compensate each other well, it is often difficult to detect the deformity when dressed.

THORACIC curves, which amount to about one quarter of the total, have a grave prognosis (Fig. 72). The apex is generally at the eighth or ninth thoracic vertebra. The onset is earlier, progress more rapid and the final deformity more severe than with any other type. When the age at onset is under twelve they nearly always become very severe, and even with a later start, the outlook is poor.

Treatment. The treatment of scoliosis is one of the more formidable problems confronting the surgeon and it calls for great experience and wise judgment. It is better carried out in a special clinic than by a surgeon



FIG 76 Turnbuckle cast (Risser jacket) applied to a patient with a left thoracic curve (*By courtesy of Mr J I P James*)

ho has the chance to treat this deformity only occasionally.

It is now known that the classical methods of treatment such as emedial exercises and corrective plaster jackets do not succeed in reducing e angular curvature as measured radiologically. It is very doubtful if ey even prevent an increase in deformity in those cases which, of their ature, are progressive. The only established method of actually reducing the urvature is by means of the turnbuckle cast associated with the name of isser (Fig. 76), and this must be followed by spinal fusion to maintain he correction. Operations such as placing staples or bone grafts across he bodies of the vertebræ on the convex side of the curve, or excising the pical vertebræ, are still at an experimental stage.

Correction of the curvature and the maintenance of correction is a major affair, and the procedures involved are neither so free from complications, nor so certain in result that they can be lightly advised. Correction should be attempted only when there is reason to believe that the particular curve under consideration will otherwise progress and become severe, say to more than 70°. Advice as to treatment must therefore depend on the prognosis. The few curves that most probably will become very severe—they are not more than 5 per cent of the total, and nearly all are thoracic—may be treated by correction and fusion. With the remainder, that is 95 per cent, it is better to be content with remedial methods.

REMEDIAL EXERCISES aim at maintaining the mobility of the spine, ensuring that breathing is correctly carried out and providing the best compensatory posture. Unilateral exercises designed to strengthen the muscles on the convex side of the curve were once popular, but they have been abandoned now that it is realised that they have no real corrective effect. It is important to retain the mobility of the spine in order to prevent,



FIG. 77 A boy aged 12, with a paralytic left thoracic scoliosis of 102°. This X-ray and that shown in Fig. 78 were taken with the patient standing

or delay, the onset of pain. Any good system of general exercises will do, but care must be taken, especially when there is a thoracic curve, to ensure the greatest possible use of the thoracic cage for breathing. Exercises should be continued throughout life, and not restricted to a limited period of treatment in adolescence. Alterations in posture are achieved, not so much by exercises, as by conditioning new postural reflexes (p. 40). The thorax is shifted into alignment with the pelvis, thus preventing the hip sticking out and making the shoulders level (Fig. 75).

A TURNBUCKLE CAST is almost the only method of effecting a true reduction in the curvature, but it must be followed by spinal fusion to maintain reduction. It is indicated when the prognosis is bad, as with a thoracic scoliosis of early onset. Figs. 77 and 78, for which I am indebted to Mr. J. I. P. James who treated the patient, show a true reduction in the



FIG 78 The same patient after correction in a turnbuckle cast and fusion The curve has been reduced to 60° and the thorax is above the pelvis He is still wearing a spinal support

curvature of 40 per cent, and an even greater improvement in the general alignment of the trunk.

A plaster cast to include the trunk, and usually the leg on the convex side, the opposite arm and the neck, is applied whilst the patient is suspended by the head (Fig. 76). The cast is split circumferentially at the level of the apex of the curve, and hinges are placed eccentrically on the convex side. A turnbuckle is fixed on the concave side opposite the hinges

and unscrewed over a period of days thus forcibly bending the spine around the apex of the curve. The eccentric placing of the hinges causes some elongation of the plaster and allows for the increase in length that occurs when the spine is straightened.

SPINAL FUSION. Almost the only indication is to maintain the improvement effected by a turnbuckle cast. In the past, fusion was often performed with the intention of preventing a curve increasing, but many of these operations, particularly in the lumbar and thoracolumbar regions, were quite unnecessary because the curves were not of a progressive type. Fusion is conveniently performed through a window cut in the cast by one of the methods described on p. 78.

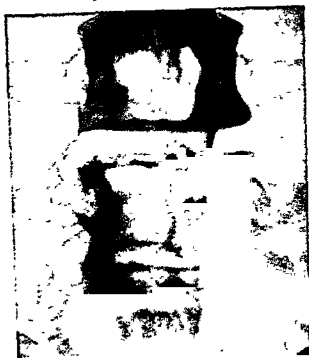


FIG 79 Spina bifida occulta. The laminæ of the third fourth and fifth lumbar vertebræ have failed to fuse There were no symptoms attributable to the defect.

SPINA BIFIDA

Spina bifida is a condition in which there is imperfect developme the neural arch, meninges, or spinal cord. A defect of the meninges or is always accompanied by failure of the laminæ to fuse, but failure of f without any other defect (spina bifida occulta) is one of the comm skeletal anomalies (Fig. 79). There are five degrees of spina bifida.

1. Spina Bifida Occulta. Some degree of failure of fusion o neural arch is present in about 25 per cent of all spines, usually in the part. The condition is nearly always symptomless and then no treat is required. Sometimes, however, there are associated troubles such cavus, and occasionally enuresis, which may be attributable to a fatty pad pressing on the cauda equina, or to a mi[illegible] of mer

myelocele. There is often an associated minor cutaneous defect such as a dimple, tuft of hair or lipoma which requires cosmetic treatment.

2. Meningocele. The meninges protrude through a defect in the neural arch (or cranium). The protrusion contains only cerebro-spinal fluid, and the spinal cord and nerve roots are in their normal position. It is usually in the mid-line of the back and is covered with normal skin, except sometimes over the apex. It is translucent, it transmits an impulse on crying or coughing, and it can be reduced in size by pressure. Operative removal may be attempted and is often successful (Fig. 80B).

3. Meningo-myelocele. This projects backwards like a meningocele but it is usually more fusiform in shape. The spinal cord or cauda equina

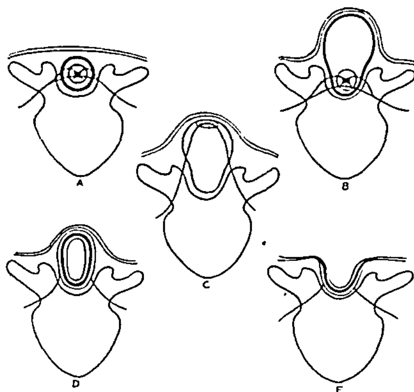


FIG 80 Spina bifida
A Occulta B Meningocele C Meningo-myelocele
D Syringo-myelocele E Myelocele

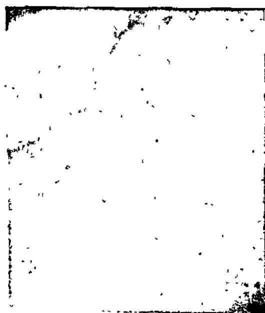
are adherent to the posterior surface of the sac and the nerve roots perforate the sac on their way to the intervertebral foramina. This type is almost always accompanied by organic symptoms which vary in severity from slight weakness of the lower extremities or sphincters to complete paraplegia. Operative interference is seldom successful (Fig. 80C).

4. Syringo-myelocele. The central canal of the spinal cord is distended and often the meninges are imperfectly developed leaving the dilated cord in contact with the skin. Children born alive are always paraplegic and seldom survive for long; operation is likely to hasten death (Fig. 80D).

5. Myelocele. The primitive medullary groove fails to close and the central canal opens dorsally on to the surface of the body. The condition is not compatible with life (Fig. 80E).

SPONDYLOLISTHESIS

The lamina and inferior articular process on each side of a lumb vertebra are joined to the lower border of the pedicle by a strip of bo known as the pars interarticularis. Sometimes this strip of bone is replac by fibrous tissue, a condition known as *spondylolisis* (Fig. 83). This a common anomaly estimated to occur in 3–4 per cent of the populatic The defect is usually bilateral and then the affected vertebra has no bo attachment to the vertebra below, being joined to it only by soft tissu In *spondylolisthesis* the affected vertebra divides at the defective poir and slides forwards together with the whole spinal column above it; on the inferior articular processes and laminæ remain *in situ* (Figs. 81 and 81



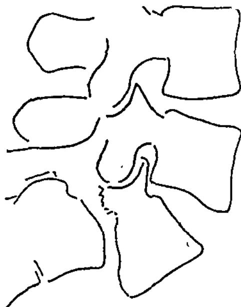


FIG 81. Spondylolisthesis The fifth lumbar vertebra is displaced forwards on the sacrum about half its depth Note the alteration in shape of the bones suggesting that the defect has been present since early in life

It is thought that in most cases the condition is due to a disorder in early development in which the two parts of the bone fail to fuse. It is probable that when there is gross displacement the shift commences before, during or soon after birth. The deformity may increase for a time, but adaptive changes in the shape of the vertebral bodies, which could only take place during childhood, indicate that there is not usually much further displacement during later life.

There is increasing evidence that sometimes spondylolisis, and perhaps the lesser degrees of spondylolisthesis, may be caused by trauma. When the diagnosis is made after an accident, it does not necessarily follow that it was caused by it; however, the X-ray appearances on occasions do resemble a fracture rather than an old-standing defect. Very severe injuries may dislocate the spine after fracturing the pars interarticularis, but the patient seldom survives.

Spondylolisthesis affects men with about twice the frequency of women. The defective vertebra in some 90 per cent of cases is the fifth lumbar and this vertebra is displaced forwards on the sacrum. The fourth lumbar accounts for most of the remaining 10 per cent, but occasionally the other lumbar vertebræ, and very rarely the thoracic or cervical vertebræ, are involved. The amount of displacement varies from a fraction of an inch to a complete dislocation in which the posterior border of the body of the upper vertebra slips over the anterior border of the vertebra below. A usual displacement is between a quarter and a half of the breadth of the body (Fig. 81).

Clinical Features

Both spondylolisis and spondylolisthesis often remain symptomless for many years, even when there is gross slipping. However, the defect in continuity of the bone makes the spine potentially unstable and a minor strain is liable to precipitate the onset of symptoms. This sometimes happens during childhood, but more often in early adult life.

Patients come under observation complaining of low backache. At first the pain is seldom severe and does not interfere with games, but it may prevent heavy manual labour. It is usually worse after bending and lifting, and often on getting up from rest. It may be intermittent and associated with particular movements, and there may be a sensation of something moving in the spine when twisting. There is a tendency for the pain to become gradually worse, and it may in time become really incapacitating. Sometimes pain is referred over the distribution of the sciatic nerve, and there may be a typical sciatic syndrome with objective motor and sensory changes, usually of first sacral type ; occasionally pressure on the cauda equina causes extensive neurological disturbances.



Fig 82 Spondylolisthesis

The shape of the back is characteristic (Fig. 82). The sacral region looks unduly long, and immediately above the fifth lumbar spine is a sharp depression which may be so pronounced as to be almost like a shelf. The depression becomes more marked if the patient, when lying prone, lifts the shoulders from the couch. The lumbar region is short and the ribs and iliac crests are closer together than in normal people.

Spondylolisthesis was first described by obstetricians and at one time was of interest only as a complication of labour. Great displacement may well narrow the pelvic brim sufficiently to prevent the passage of a baby, but many women with a considerable amount of displacement have had a normal labour.

X-rays. Gross displacement is clearly seen in lateral radiographs (Fig. 81). It can often be recognized in antero-posterior views because the line of the lower border of the fifth lumbar vertebra merges into that of the lower borders of the transverse processes making a shape like a bow which the French describe as resembling a gendarme's helmet. Lesser degrees can sometimes be detected in lateral views by drawing a line perpendicular to the upper surface of the sacrum at its anterior angle; this line normally *touches the antero-inferior angle of the fifth lumbar vertebra.*

Spondylolisis and very minor degrees of spondylolisthesis can only be demonstrated in oblique X-rays. These are easier to interpret when the neural arch is visualized as a picture of a "terrier". I do not know who was originally responsible for this ingenious idea, but it was pointed out to me by Watson-Jones. The head of the "terrier" is formed by the pedicle and transverse process, the ears by the superior articular process, the neck by the pars interarticularis, the body by the lamina, and the front legs by the inferior articular process. The normal appearance is shown in the third lumbar vertebra in Fig. 84. When the "terrier" has a collar on, as in the fifth lumbar in Fig. 83, there is a defect at the pars interarticularis *without* displacement (spondylolisis); when the "terrier" is decapitated, there is spondylolisthesis (Fig. 84).

Treatment

With both spondylolisis and spondylolisthesis, when the symptoms are mild, it is worth while prescribing remedial exercises to strengthen the erectores spinæ, and advising such steps as are practicable to avoid straining the back (p. 74). Manipulation can be helpful and it is worth a trial, particularly if there are secondary symptoms in other parts of the back.

Symptoms following immediately after an accident should, when the X-ray appearances are compatible with a recent fracture, be treated by immobilization in a plaster corset for some months because it is thought that this may permit union by bone.

Severe pain can be relieved only by immobilization (p. 76). A surgical corset may be sufficient, and one should be ordered if the patient is prepared to give it a trial. Spinal fusion is indicated when conservative measures have failed, and sometimes for economic reasons in heavy workers. It is also desirable when there is severe sciatic pain but the extradural portions of the nerve roots should be explored at the same time. Fusion may be performed by any of the standard methods, but it is usually rather difficult because of the frequency with which the first sacral spinous process is deficient or absent. Anterior fusion between the bodies of the vertebræ, first described by Burns, has often been carried out successfully but it is not a routine procedure.

Reduction of an old-standing lesion is quite impossible but, on the few occasions when there is evidence that the displacement has increased recently, it may be attempted. The patient is placed in bed for several days with the pelvis lifted on a canvas sling suspended from a Balkan beam and traction is applied to both legs.

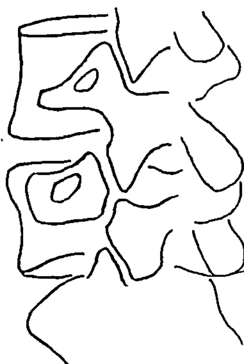



FIG 83 Spondylolisis There is a defect in the pars inter-articularis of the fifth lumbar vertebra: the "terrier" has a collar on

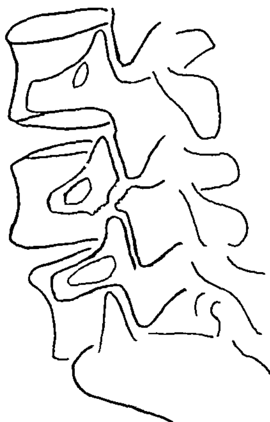



FIG 84 Spondylolisthesis The fourth lumbar vertebra is displaced slightly forwards on the fifth the "terrier" is decapitated

OSTEITIS CONDENSANS ILII

This is a condition in which there is alteration in the structure of the ilium adjacent to one or both the sacroiliac joints. X-rays show a small area of sclerosis in the portion of the ilium lying immediately behind the cartilage covered, auricular surface (Fig. 85). The joint itself is normal and the sacrum is not affected. Histological examination has sometimes shown an increase in the number and thickness of the trabeculæ in the affected bone.



FIG 85 Bilateral osteitis condensans ilii

The changes are seen more frequently in women than men. often in young women during the later months of pregnancy. The chief complaint is said to be of low back pain which radiates into the buttock and is made worse by activity and relieved by rest. Specific physical signs are notably absent and the diagnosis can only be made radiologically. Some surgeons claim that relief is given to a high percentage of patients simply by correcting postural defects and increasing the amount of rest.

There is grave doubt as to whether the condition does in fact give rise to any symptoms whatsoever and therefore it has not been included amongst the causes of low back pain. It is mentioned here only because it figures in radiologist's reports, and if it is accepted as a cause of symptoms, the search for the real cause may be neglected. Low back pain is common in both young women and in pregnant women, and it is often relieved by rest whether there happens to be a variation in the structure of the ilium or not.

TORTICOLLIS

It is customary for historical reasons to classify together the different varieties of wry-neck although this may be the single symptom that a number of entirely different diseases happen to have in common. The term "torticollis" is now identified with the commonest of them, "*congenital*" *sternomastoid torticollis*, a condition occurring in infants in which the primary defect is in the sternomastoid muscle (or its blood supply). It would be advantageous if the other causes of wry-neck were associated only when discussing the differential diagnosis.



Fig 86. Right torticollis

In "congenital" sternomastoid torticollis, the sternomastoid muscle fails to increase normally in length during early growth. Histological examination of the muscle shows that it contains more interstitial fibrous tissue than usual, and also fibrous patches resembling old scars. If the deformity is left uncorrected for some years, the other soft tissues in the neck are shortened and the vertebræ become altered in shape in adaptation to the abnormal posture.

There is doubt about the ætiology. At one time it was believed that the trouble was caused by injury during birth; the small tumour in the muscle that is often present soon after birth was thought to be a hæmatoma, and it was assumed that a few muscle fibres were torn. Later it was shown that acute flexion of the neck during delivery could obstruct the venous return and it was suggested that the muscle fibres suffered damage

from anoxia. These theories are no longer accepted and the present vie is that the condition is akin to Volkmann's contracture and is caused b interference with the arterial blood supply (p. 373). It is possible that very few cases are due to an amyoplasia similar to that in arthrogryphos

Symptoms

A "sternomastoid tumour" is sometimes present, but not always, or very soon after birth. It consists of fibrous tissue and forms a ha lump in the substance of the muscle; it gradually decreases in size a eventually disappears.

Restriction of movement of the neck may be noticed by an observa mother at the age of a few months. Deformity is not usually visible until about a year and then it slowly increases because the sternomastoid fails to grow at relatively the same speed as the cervical spine. When the characteristic appearance has developed, the contracted muscle stands out like a cord and the head is pulled to one side and tilted so that the face looks upwards and to the opposite side (Fig. 86). If untreated, the deformity may become very severe, and by the time adult life is reached there is a compensatory upper thoracic scoliosis and elevation of the shoulder which make the general appearance most unsightly.

Facial asymmetry develops at the same time as deformity of the neck. The half of the face on the side of the affected muscle becomes smaller and shorter, and the eye lower than the other. Asymmetry is less noticeable when the head is on one side, and more obvious when the head is straight and the rest of the body covered up.

Double torticollis in which both sternomastoids are affected has occasionally been reported. The neck, as viewed from the front, is straight, but it appears short and the face is tilted upwards.

Differential Diagnosis

Other possible causes of wry-neck include :—

Habit
Bony abnormalities of the cervical vertebræ.
Tuberculosis of the cervical vertebræ.
Ocular torticollis.
Paralysis of one sternomastoid or other cervical muscles.
Cicatricial contraction.
Reflex Irritation. Inflammation of cervical lymph glands.
otitis media.
parotitis.
Spasmodic torticollis.

Some children form the habit of holding their heads to one side without discoverable cause; the sternomastoids are normal, there is a full range of active and passive movements, and no ocular defect. The habit is readily corrected by re-educational methods.

Developmental defects and diseases of bone are excluded by X-rays.

Ocular torticollis may occur in children or adults with good binocular vision but with overaction of one or more of the ocular muscles that elevate or rotate the eye. An abnormal position of the head is taken up in order to make the visual axes parallel and obviate the diplopia which would otherwise result. The usual muscle to be affected in children is the inferior oblique which both elevates the eye and rotates it externally. The elevating action is mechanically greatest when the eye is adducted, and absent when it is abducted. Therefore, when there is overaction of one inferior oblique, the head is habitually held turned to the opposite side and the eyes to the same side so as to keep the affected eye abducted; there may also be a variable amount of tilting of the head (A. J. B. Goldsmith).

Spasmodic torticollis is a functional nervous disorder in which clonic contraction of the muscles of the neck, including the sternomastoid, is but one manifestation of an hysterical condition. Its treatment is entirely outside the province of surgery.

Treatment

Conservative. In infants, at the stage when there is limitation of movement of the neck but little or no deformity, it is often possible to restore the full range of movements by repeated passive manipulation. The head is held between the hands and carried towards the opposite shoulder, then rotated in the same direction and finally the neck is extended. This is best carried out by a physiotherapist who is familar with the normal range, and not by the child's mother who is likely to be frightened of causing damage. Full correction is usually obtained in a few weeks and in most patients development then proceeds normally; the child should however, be kept under regular observation for at least a year because occasionally there is a relapse and tenotomy is necessary.

Operative. Division of the sternomastoid is necessary in older children and it should be carried out as early as possible before other structures in the neck have contracted, and before facial asymmetry is marked. Asymmetry is more obvious for a time after operation, but provided the neck is straightened whilst the child is still young, the face gradually returns to normal over a period of years; it is unlikely to recover completely in children over eight or ten years of age at the time of operation.

The sternomastoid can be divided at open operation or by subcutaneous tenotomy just above the clavicle; the latter is quite satisfactory in young children. In older children the deep cervical fascia may be contracted and require division also; this is conveniently managed, and with an inconspicuous scar, through a transverse incision in one of the creases of the neck. A severe contraction may require division of both ends of the sternomastoid; the upper end is approached through a transverse incision just below the mastoid process. It is not advisable to operate on young adults if there are adaptive changes in the shape of the vertebræ.

Proper after-treatment is essential. Some surgeons attempt to fix the head straight for several weeks by a collar of ...

apparatus does this efficiently. If the child is old enough to co-operate it is better to rely on educative methods. The child has to learn what i feels like when the head is straight—he has to condition a new reflex. H is placed in front of a mirror, his eyes are covered, and he is told to put hi head straight : then his eyes are uncovered and he can see the result. Th is repeated until the proper postural sense is acquired.

CONGENITAL ELEVATION OF THE SCAPULA

(*Synonym*) Sprengel's Deformity

This is an uncommon congenital deformity in which the should girdle, which develops as a cervical appendage, fails to descend proper during early fœtal life. The scapula is higher than its fellow and usual rotated so that its lower angle is nearer the vertebral column (Fig. 87 The scapula may also be smaller than normal and the upper part hook forwards round the upper border of the thorax. The condition is occasionally bilateral.

In most instances there are other congenital defects and deformities of the ribs, vertebræ and muscles ranging in severity from spina bifida occulta to congenital wedge vertebræ and amyoplasia. Often there is a fibrous band, or a cartilaginous or bony bar, joining the scapula to the spinal column, usually the fourth to seventh cervical spinous processes, and this greatly restricts movement of the shoulder girdle.

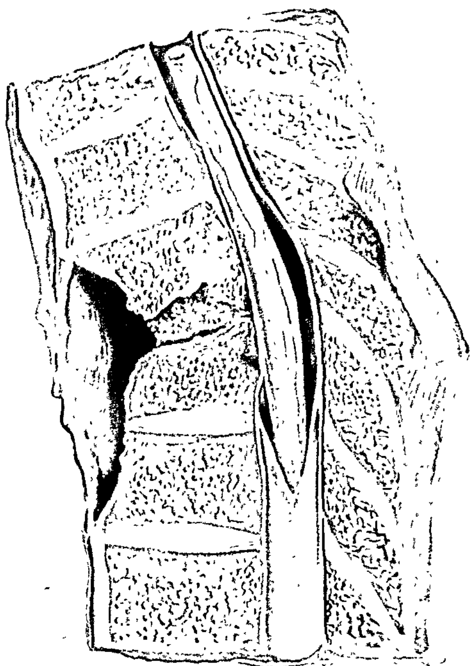


Fig. 87.

Treatment

When the deformity is only of moderate severity, some benefit may be derived during infancy from passively stretching the muscles supporting the shoulder girdle, and at a later age from mobilizing exercises.

Operation seldom gives a really good result, but even with severe deformities it may improve the general appearance and increase the mobility of the ar A wide exposure is made and the muscles are detached from both upper and vertebral borders of the scapula, and from the spinous process an abnormal bar of bone or band of fibrous tissue is removed and also it is hooked forwards, the upper part of the scapula itself. It may th be possible to pull the scapula lower down the thorax, but there is a str tendency, even if it is anchored to one of the ribs, for it to ride up ag later. When there are multiple congenital deformities, particularly defe of the vertebræ, scoliosis may be the major therapeutic problem and position of the scapula is ignored.



Tuberculous Disease of the Spine.
(By courtesy of Mr H J. Seddon)

TUBERCULOSIS OF THE SPINE

Tuberculous disease of the spine, first described in English by Percival Pott in 1779, is essentially a disease of childhood. About 70 per cent of cases start between the ages of two and five years, and 15 per cent between five and ten years; the remaining 15 per cent *are distributed fairly evenly* through the rest of life. The spine is the commonest site of bone and joint tuberculosis and accounts for about half the total. The incidence is greatest in the lower dorsal region, and then in the lumbar, upper dorsal and cervical regions in that order of frequency. The sexes are affected equally.

Pathology

The initial focus of infection is most commonly in the body of a vertebra close to one of the hyaline cartilage plates, and only occasionally elsewhere, e.g. the intervertebral joints or spinous processes. The area of infection enlarges until several adjacent vertebræ are involved; sometimes there is dissemination to a distant vertebra *via* a paravertebral abscess (Plate I).



Fig 88 Paravertebral abscess, fusiform type

The bodies of the affected vertebræ are gradually destroyed until ultimately they collapse. The neural arch and intervertebral joints usually remain intact and therefore the bones do not telescope, but angulate sharply forwards. The amount of angulation depends on the extent of destruction and the number of vertebræ involved (Fig. 91).

The [illegible] usually [illegible] ult of [illegible] when the adjoining vertebræ are destroyed, and not because of direct invasion by the tuberculous process to which they are very resistant.

Repair is by fibrous replacement of the tuberculous tissue and this is more readily accomplished after collapse, which reduces the total area concerned, than if collapse is prevented during treatment. In the course of time the fibrous tissue may be converted into bone; ossification starts peripherally and spreads inwards, but is exceedingly slow. Abscesses gradually dry up when the disease becomes quiescent leaving a mass of inspissated material which may also partly calcify.

Abscess Formation. This is so usual an event that it can hardly be

called a complication. The abscess is a thick walled structure lined with tuberculous granulation tissue and containing a quantity of thickish matter which consists of serum, caseous material, degenerate tissues and blood cells. The volume produced may be very large and as much as a pint a week has been aspirated from a single abscess. Some abscesses are small and localized but others track far in a direction determined by the fascial planes. The fascia may be perforated when the abscess is under tension by reason of the small space available for it, or the large volume of fluid.

The typical lumbar abscess enters the sheath of the psoas muscle at its attachment to the vertebræ and comes to the surface below the inguinal ligament, but occasionally it enters the femoral canal and appears much lower in the leg. A lumbar abscess may also track backwards with the lumbar vessels passing between the erector spinæ to present in the back near the mid-line.



Fig 89. Paravertebral abscess, "bird's nest" type

Dorsal abscesses are confined by the longitudinal ligaments which give less freedom for expansion. The typical abscess produces a fusiform paravertebral swelling (Fig. 88), but it may burst into the mediastinum where it is walled off to form the "bird's nest" type (Fig. 89). Occasionally a dorsal abscess follows the vessels along an intercostal space and presents by the sternum. A cervical abscess is confined by the prevertebral fascia and may burst into the pharynx or track laterally.

The "aneurysm phenomenon" is an interesting feature sometimes seen in connection with an abscess. The pulsation of the aorta is transmitted by the fluid abscess to the spinal column. The intervertebral discs and epiphysial rings are dense enough to remain unaffected, but the intermittent pressure causes absorption of the softer bone betwe rings (Fi . 9

Clinical Features

Tuberculosis of the spine is an insidious disease which may fail to attract attention until a fall or minor injury causes pain. The first symptoms are easily overlooked ; there may be no more than an unwillingness to play outdoor games or to romp, or undue fatigue, or a slight limp when tired. The characteristic signs and symptoms develop later.

Pain. There is seldom severe pain, even with advanced disease, and as a rule the patient is apprehensive rather than in pain. Sometimes there is an ache in the back, sometimes the pain is referred segmentally to the ear, stomach, etc. Movements, specially twisting and jarring the back, make the pain worse, and there is a tendency to avoid certain actions such as jumping, or riding in a bus.

Limp. The gait is affected when the spine is stiff because of muscle spasm, or when there is a psoas abscess, and therefore limp is common in lumbar disease and may be the first sign to be noticed. Sometimes there is not so much a limp, as a peculiar mincing way of walking.



FIG 80 Tuberculous disease of the ninth and tenth thoracic vertebræ

Tenderness. There is often, but not always, tenderness on pressure on gentle percussion over the spinous processes of the affected vertebræ. eavy percussion or forced passive movements may cause injury at the te of disease and must not be used during examination.

Protective Muscle Spasm. This is a constant feature. The spine is eld rigid and stooping avoided ; bending, as when picking up an object om the floor, is done from the hips and knees instead of the back. Spasm small children is detected by lifting up the legs when lying prone.

Deformity. Some kyphosis is often visible early in the disease and ay be the first thing to be noticed. To begin with there is no more an the slightest alteration in the normal curve, but later the angulation ecomes acute and the spinous processes at the apex project like a knuckle

(Fig. 90). Extreme deformity compresses the thoracic and lumbar viscera and may distort the main blood vessels causing cardiac hypertrophy.

Abscess. The usual sites for an abscess to present are the groin and the loin, and sometimes it appears very early. The abscess forms a large fluctuatant swelling which, in the groin, may be mistaken for a hernia

Diagnosis. In children diagnosis can often be made on clinical ground alone—deformity and muscle spasm are nearly sufficient evidence—bu radiological confirmation must always be sought. Indeed, radiology is routine procedure for every patient of whatever age who has symptom which can possibly be referable to the back. The early changes in tuber culosis are irregularity in outline of a vertebral body, decalcification diminution in depth of the body and narrowing of the intervertebral spac (Fig. 93). Abscess shadows may be visible very early; the psoas sheat normally is clearly outlined and alteration in its shape is of great diagnosti importance. At a later stage X-rays show gross destruction of bone, th intervertebral discs disappear, the vertebral bodies collapse, and sometim there is sequestrum formation.

In adults it may be very difficult to distinguish tuberculosis from new growth, usually a secondary deposit, because of the variation in tl X-ray appearance from patient to patient. At a younger age, adolesce kyphosis may closely simulate tuberculosis but the outline of the bodies the vertebræ is intact except at the angles, and there is no general rar faction or abscess formation (Fig. 62, p. 98).

Paraplegia

This grave complication formerly occurred in about 11 per cent of patients with Pott's disease (R. W. Butler) but the incidence has probab been reduced by chemotherapy.
because of the narrowness of th
rarely in children, paraplegia r

The causes and the prognosis are somewhat different when the onset paraplegia is early from when it is late in the course of the disease. T following account is based on a recent study by H. J. Seddon.

Early onset whilst the disease is still active. The cause is pressu on the cord by either (1) an abscess or a caseating mass developing behi the vertebral bodies (or occasionally in the neural arch), or (2) a ridge living bone or a sequestrum of dead bone squeezed backwards as t vertebræ collapse and angulate (Fig. 91).

Late onset occurring perhaps years after the disease has apparen healed. Sometimes it is due to a tuberculous granuloma developing behi the vertebral bodies, and sometimes to an interstitial gliosis involv the cord at a point where the spine is acutely angulated.

The symptoms, which often resemble those of a spinal tumour, are in the main to compression of the cord, although œdema, and perh thrombosis of the blood vessels supplying the cord, may be aggravat factors. The usual lesion gives rise to a spastic paraplegia with disturba of motor and sensory function, and sometimes of sphincter control.

may be found in late paraplegia.

TREATMENT is primarily conservative. The spine is hyperextended on a hinged plaster bed or an angulated frame, and antibiotics are administered. Operative decompression is advisable when voluntary control of the muscles fails to return within a month, or at most two months. The bodies of the vertebræ are exposed by costo-transversectomy or by an antero-lateral approach, the pus is evacuated and caseous material, sequestræ and live bone are removed as may be found necessary.



FIG 91 Tuberculous disease involving the ninth to twelfth dorsal vertebræ. Note the "aneurysm phenomenon" at the eighth and ninth vertebræ (p 130)

Treatment

General. The principles of treatment are the same as for tuberculosis elsewhere—rest with proper conditions of food and hygiene (p. 428). Chemotherapy is of less obvious benefit than elsewhere, although there are occasional startling successes. A full course lasting for six months is commenced as soon as the diagnosis is established, and it may have to be repeated if operative intervention is later found to be necessary.

Local. The conditions of rest are designed (*a*) to prevent as far as practicable all movement of the back, (*b*) to minimize bone destruction and prevent unnecessary deformity, and (*c*) to produce compensatory curves.

This can be achieved by immobilization on a hinged plaster bed or on a frame. At first the back is hyperextended; this position is not adopted with the idea of preventing ultimate collapse, but of protecting the diseased bones from pressure and unnecessary destruction during the active stage. Hyperextension is continued until the active stage is complete and then the vertebræ are allowed to fall together and compensatory curves are developed. Compensatory curves are produced by padding above and below the kyphus, and the closer the curves are to the kyphus, the better is the cosmetic and mechanical result. Careful watch is kept for abscesses presenting at the surface, and should this happen they must be aspirated regularly to prevent perforation of the deep fascia and skin.

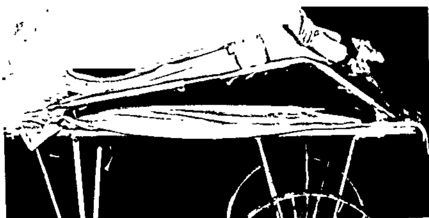


FIG 92. Hyperextension on a frame (Royal National Orthopædic Hospital by courtesy of Mr H J Seddon)

Hinged plaster beds are preferred to frames at many centres because although they are more trouble to make, they are easier to adjust and offer better facilities for nursing. A frame consists of a rectangle of metal tubing with canvas stretched across. It is bent to suit the individual patient and can be adjusted as the occasion requires. The bed (or frame) is mounted permanently on a carriage for easy transport in and out of the open air (Fig. 92). An anterior plaster shell is made to permit occasional turning without excessive movement of the back.

X-rays are taken at regular intervals throughout treatment and provide an almost cinematographic record of progress. Decalcification and destruction gradually cease, recalcification commences and eventually a ring of dense bone forms around the diseased area (Fig. 93). Recumbency is continued uninterruptedly until healing is well advanced. Before the patient is allowed up he should be putting on weight, and there must be freedom from pain and radiological evidence of satisfactory recalcification The usual time for a child is from one and a half to two years.

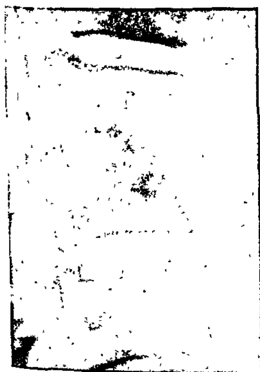
Some support for the back, either a plaster jacket or spinal brace, is essential when the patient first gets up. He should lead a protected life and remain under the close supervision of the medical team that was responsible for his care in hospital. This entails regular clinical and radiological examination at that hospital or its associat ter-care c



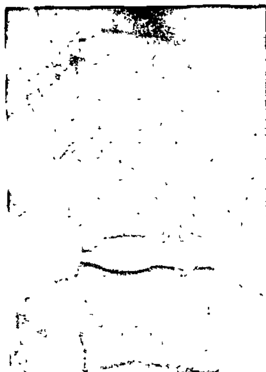
December 1950



April, 1951



August 1951



May 1952

Fig 93 Tuberculous disease showing early arrest followed by repair (by courtesy of Mr M C Wilkinson)

Operative. Decompression. Evacuation of an abscess and the removal of caseous material or sequestræ may be called for when there is paraplegia.

Spinal Fusion (p. 78) is often desirable at some stage but it must not be used as an alternative to conservative methods or else collapse of the diseased bone, and consequently healing, may be prevented. The operation is usually performed late with the intention of protecting a well-healed lesion against trauma. The best time is probably after the patient has lead an active life for several years with only the protection of a brace, and without any sign of re-activation; some surgeons prefer not to wait so long and fuse the spine as the last stage of primary treatment

SACROILIAC TUBERCULOSIS

Tuberculosis affects the sacroiliac joints less often than the spine or hips but it is by no means infrequent. It occurs chiefly in young adults, the maximum incidence being between sixteen and thirty-five years of age. It is one of the more serious joint affections because of the frequency of associated tuberculous lesions and of sinus formation. Obvious tuberculous lesions are present elsewhere, often in the lungs or spine, in about one-third of all cases. The prognosis in children compares reasonably with other sites, but the mortality increases with age. The adverse effect of associated lesions and of sinuses has been modified to some extent by chemotherapy.

Clinical Features

The principle symptoms are pain and limp. The onset is insidious and the diagnosis is often overlooked until pain has become prominent. Pain may be felt at the sacroiliac joint, in the low lumbar spine or in front of the hip, and it may be referred along the course of the sciatic nerve. Limp may be due to an abscess tracking around the hip joint, or it may be associated with the "scoliosis" which not infrequently develops.

Abscess formation is very common and sometimes the first sign to appear. The abscess usually presents posteriorly over the joint but it may track to the loin, groin, buttock or indeed almost anywhere around the pelvis. Nearly half the patients have sinuses at some stage in the disease.

Resolution is by fibrous tissue formation leading to fibrous ankylosis. Spontaneous ossification takes place in many cases over a period of years, even in the absence of secondary infection.

X-rays (Fig. 94). At an early stage, diagnosis may be difficult because the general rarefaction of bone usually seen around a tuberculous joint is often absent. The earliest sign is erosion of the joint surface, and later there is cavitation of the adjacent portion of the sacrum or ilium. Erosion and destruction may be limited to part of the joint or involve the whole of it. The joint space may appear narrower or broader; it is narrower when the joint surfaces are destroyed and the bones fall together, but broader when bridges of stronger bone remain and pre[illegible] collapse.

Treatment

Conservative treatment is even more important than usual because of the frequency of associated lesions. The usual regime is instituted (p. 428) and the patient placed on a plaster bed. Only a relative degree of immobilization can be obtained because movement of any part of the legs or spine affects the sacroiliac joints. Careful watch is kept for abscesses and the patient is turned on an anterior plaster shelf once or twice monthly for inspection. Recumbency is continued until radiographs show commencing resolution; this seems to occur more quickly than at the spine or hip, perhaps because treatment is often begun later.



Fig. 94. Tuberculous disease of the left sacroiliac joint

Operation. Two operative procedures are commonly practised, excision of the diseased bone and arthrodesis.

Excision. The accessibility of the joint to radical surgery is a temptation to attempt complete eradication of the disease but this should be considered only after a period of conservative treatment, preferably when the general condition is satisfactory and local resolution has commenced. Occasionally excision is worth attempting as a last resort when the patient is unable to build up resistance against a massive infection. The usual procedure is that of *Picqué* who approaches the joint by removing the ilium posterior to a vertical line extending from the iliac crest to the sciatic notch.

Arthrodesis is used to provide protection after the active phase is arrested, or when the disease is quiescent. Extra-articular fusion can be carried out by *Verrall's* method in which a tibial graft is placed so that the ends pass through the overhanging portions of the ilium on each side, and the central part lies in a bed cut on the dorsum of the sacrum. *Campbell's* method is also suitable.

OSTEOMYELITIS

Acute osteomyelitis of the spine may be caused, as in other bones, by any pyogenic bacteria, but the commonest is the staphylococcus aureus (Chap. X). *The infection is usually blood-borne although an infected* lumbar puncture needle is an occasional source of trouble.

There are three types :—

(1) More often seen in children and adolescents. The osteomyelitis is but part of a fulminating septicæmia and calls for no local treatment.

(2) Usually seen in adults :—

(*a*) The initial infection is in the neural arch or its appendages. The onset is often acute with high fever, extreme tenderness, rigidity o the spine and subcutaneous œdema.

(*b*) The initial infection is in the body. The onset is usually insidious and for months the cause of the illness may pass unrecognized unt at last a deformity develops which resembles that in tuberculosis At first there may be onl general malaise and irregula pyrexia, a little pain in the bac and some tenderness; ofte flexion of the spine is markedl restricted whilst extension i free.

Mediastinitis is an almo invariable complication of in fection of the body and lead sooner or later to the develop ment of a mediastinal absces empyema or suppurative per carditis. Respiratory symp *toms are therefore prominen* The formation of an extradur abscess within the spinal cana not infrequently follows infe tion of the body, but seldo infection of the neural arc The abscess or surroundin œdema may compress the spinal cord causing paraplegia.

X-rays. Radiological changes are slow to develop and none may be seen during the early weeks. The first sign when a body is involved may be narrowing of the intervertebral space. This is followed by changes in the trabecular struc-

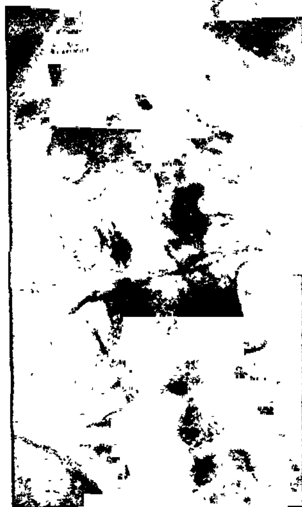


FIG 95 Healed osteomyelitis of the bodies of the first, second, third and fourth lumbar vertebræ three years after the acute phase

re of the bone and later the body is destroyed and may collapse. Seques-e are common. During the healing stage much reactive new bone is rmed with exostoses and bridges between the affected bodies (Fig. 95). eural arch infection is harder to detect and may only be demonstrated ter the bone has been destroyed. Oblique views are of value to show volvement of the lateral intervetebral joints.

Diagnosis. This is often exceedingly difficult because of the complex mptomatology which varies with the vagaries of secondary infection of her structures. Many patients, perhaps most, are first investigated on ccount of pulmonary symptoms. Attention should, however, be drawn the spine by pain and tenderness on pressure over a spinous process and mitation of movements of the back.

Treatment. Penicillin in massive doses controls infection by any nsitive organism but does not necessarily terminate the illness abruptly . 406). Extradural abscess requires immediate drainage by laminectomy r costo-transversectomy. If there is gross destruction of bone, the spine hould be protected during consolidation, usually by recumbency on a laster bed.

TUMOURS

Every benign or malignant tumour that occurs in bone may be found the vertebræ, and also every dystrophy of bone and many disorders of etabolism and of the blood. The whole range of diseases from giant cell umour to sarcoma, from Albers-Schönberg's disease to achondroplasia, nd from renal rickets to lymphadenoma, are seen occasionally, but oo rarely to warrant separate lescription here.

Carcinoma

The commonest malignant umour to be found in the spine is a secondary deposit of a carcinomatous growth. Sarcoma, primary or secondary, does occur, but infrequently. The site of origin of metastatic tumours in the vertebræ is stated by Burns and Ellis to be prostate 40 per cent, breast 30 per cent, hypernephroma 7 per cent, and others comparatively rare. Metastases from the breast lodge in the vertebræ more frequently than in any other bone.

Metastases are usually deposited in the bodies of the vertebræ which are rapidly destroyed by the growth and then



FIG 96 Secondary deposit in the eleventh dorsal vertebra from a carcinoma of the breast.

collapse more or less completely (Fig. 96.) Sometimes, however, the bone increases in density to such an extent as to merit the description "ivory vertebræ" (p. 179). Pain at the site of the deposit is the outstanding feature but frequently there is also pain referred within the corresponding spinal segment. Examination shows local tenderness restriction of movement due to muscle spasm, and also deformity when the affected bone has collapsed.

Radiotherapy is often successful in relieving pain, and it may destroy the deposit enabling the bone to heal; even though the disease is not cured, life is prolonged. Occasionally the pain is so intractible that the only way of giving relief is by lateral or median cordotomy.



FIG 97 Angioma

Angioma

This condition requires special mention because of its comparative frequency. Schmorl found angiomata in about 10 per cent of spinal columns examined post-mortem by serial section, and this has been confirmed by other pathologists. The number detected radiologically, however, is very much smaller, and those causing symptoms are fewer still. X-rays show a circumscribed area of very coarse trabeculation with approximately the same arrangement as in normal bone. Usually only one vertebra is involved and chiefly the body of the vertebra, although in most instances the tumour spreads into the pedicle and transverse process on one side at least (Fig. 97). Symptoms are uncommon but they may be caused by collapse or by pressure on the spinal cord.

CHAPTER IV

THE HIP

The hip joint provides some of the major problems in orthopædic surgery. Functionally, it is one of the most important joints; it enables the body to move forwards during locomotion, it transmits the body weight, and it plays a major part in the regulation of posture whether standing or sitting. And because the hip moves with every change in position of the trunk or legs, a painful hip interferes greatly with normal activity. Unfortunately the structure of the joint is such as to render it particularly susceptible to disorders of a mechanical nature; it is a deep ball and socket joint and the very depth of the socket, although important in providing stability, has the disadvantage of requiring perfect congruity of the bearing surfaces, hence any defect seriously interferes with its smooth working. It is, therefore, almost certain that every hip not mechanically perfect will sooner or later develop osteoarthritis; in fact this crippling complaint dominates the prognosis in all disorders of the hip, and it is an almost inevitable sequel to injury or disease of every sort both in young people and in old.

The treatment of disorders of the hip is particularly difficult and calls for great judgment. When it is possible to restore congruity of the joint surfaces it is clearly desirable to do so even if, as may be the case with a child, it entails months or years of recumbency; but when it is certain at the outset that a perfect result is unobtainable, it is necessary to decide whether a difficult or a time-consuming procedure is likely to achieve a commensurate result. Some of the most difficult problems, however, are in connection with osteoarthritis in elderly people because then the pain and disability suffered by an individual patient has to be assessed and weighed against the disadvantages of undergoing a major operation, perhaps followed by a prolonged period of after-treatment, and perhaps requiring extensive adjustment in the posture and function of other parts of the body.

On the other hand, the diagnosis of diseases of the hip is seldom difficult, provided the help of X-rays is available, and it is only occasionally that a real problem arises, for example the early recognition of tuberculosis in children. It should be unnecessary to burden the memory with the more complicated clinical procedures, such as mapping out Nélaton's line and Bryant's triangle because the information they yield is unreliable, but candidates for qualifying examinations are often expected to have this knowledge. Almost every known disease of bones and joints can affect the hip, many of them are rare and can be identified with certainty

only after radiological examination. The commoner complaints can almost be diagnosed by the age at onset:—

Infants.	acute suppurative arthritis.
	congenital dislocation.
Children and adolescents.	transient synovitis.
	tuberculosis.
	Perthes disease.
	adolescent coxa vara.
Adults.	osteoarthritis.

EXAMINATION

Standing. Deformity of the hip is reflected in the posture of the pelvis and spine (Chap. I). Flexion deformity is compensated, when the knee is straight, by lordosis which may completely mask the position of the hip (Fig. 99); but if the spine is stiff or the deformity is considerable, the knee cannot be straightened and only the toes touch the ground (Fig. 134, p. 176). Abduction deformity causes apparent lengthening of the limb, and



FIG 98 Estimating the relative length of the legs

adduction causes apparent shortening, because the pelvis is tilted sideways to make the legs parallel and the heel of the shorter side cannot be placed on the ground when the knees are straight (Fig. 100).

Shortening is estimated at least as accurately when standing as it can be measured with a tape in the lying position. The patient stands with feet together, heels on the ground, and knees straight whilst the examiner places the thumb of each hand on the anterior superior spines of the ilium; the vertical distance of one thumb above the other equals the difference in length of the limbs (Fig. 98). Alternatively, blocks of wood of known thickness are placed under the foot on the short side to make the anterior superior spines horizontal. A slight difference in real length is quite common in "normal" adults who are seldom aware of it unless it exceeds one-third of an inch; a smaller amount causes no symptoms and requires no treatment.

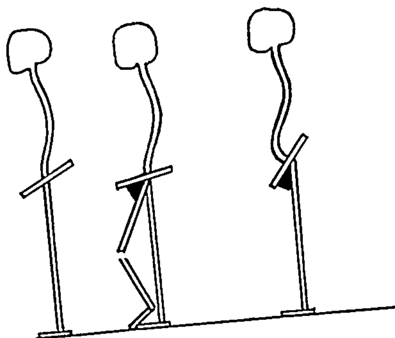


Fig 99

Normal — *Flexion Deformity* causes apparent shortening *or* lordosis

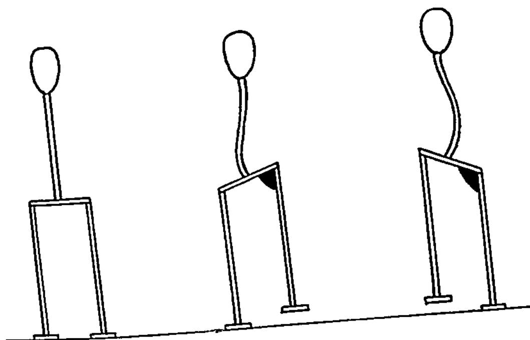


Fig 100

Normal — *Adduction Deformity* causes apparent shortening — *Abduction Deformity* causes apparent lengthening

Trendelenburg's Sign is an index of the ability of the gluteal muscles to abduct the hip whilst weight-bearing. The sign is positive when abduction is impossible by reason of weakness of the glutei (e.g. due to anterior poliomyelitis), or because their leverage is reduced, as in congenital dislocation of the hip and coxa vara. It is elicited by instructing the patient to stand on the affected leg and raise the other knee as if marking time. Normally the buttock of the raised leg is lifted to a higher level than that of the standing leg; when the sign is positive, the buttock of the raised leg drops to a lower level than the other (Fig. 101).

Gait. The cause of limp can be seen when the patient walks undressed. If the limp is caused by pain, the weight is lowered carefully on to the affected side, the knee bends slightly to absorb the shock, and the length of the step is shortened so that the weight can be taken off the leg quickly. If the limp is due to a stiff hip, the whole trunk and the affected leg are swung forward as one piece from the sound hip. If there is apparent shortening, the heel of the short side does not touch the ground. The Trendelenberg gait, when Trendelenberg's sign is positive, is characteristic and the trunk rolls across the supporting foot at each step.

Muscle Spasm. This is pronounced whenever the joint is in an irritable condition due to an inflammatory process, either infective or traumatic. Movement is free during part of the range but it is suddenly checked by spasm which can be seen and felt, and the patient is apprehensive of any attempt to use force. *Gauvain's sign,* which is very commonly present in tuberculosis, is a special example of reflex muscle spasm. It is elicited by rotating the extended hip thus causing the abdominal muscles of the same side to contract.

Lying. *Limitation of movement* at the hip is masked by movement of the pelvis and therefore the pelvis must be watched whilst examining passive movements of the hip. One hand is placed on the pelvis and the leg is moved with the other; movement of the pelvis indicates that the limit at the hip has been reached.

Fixed deformity of the hip is recorded in degrees. Abduction or adduction deformity is indicated by the angle between the line joining the anterior superior spines and the axis of the limb (Fig. 100). Rotation is noted both in extension and with the hip and knee flexed to a right angle. Fixed flexion deformity is demonstrated by flexing the sound leg until the knee touches the chest; this rotates the pelvis and extends the other hip which, when normal, should extend sufficiently for the leg to remain flat on the couch; inability to keep it flat indicates limitation of extension (*Thomas' test,* Fig. 102).

Real shortening is often estimated by measuring with a tape the distance between the anterior superior spine and internal malleolus on each side. The method is inaccurate because of the difficulty in defining these points precisely, and because the legs cannot be placed symmetrically when there is fixed deformity. *Apparent shortening* measured from the umbilicus to the internal malleolus is even more inaccurate because the umbilicus is not necessarily central in corpulent people.

Fig 101 Trendelenberg's sign is negative for the left hip and positive for the right





Fig 102 Thomas' test in a child with tuberculous disease of the left hip.

Nélaton's line was described in 1847 to assist in the diagnosis o traumatic dislocation of the hip. The line joins the anterior superior spi of the ilium to the most prominent part of the ischial tuberosity. Nélat

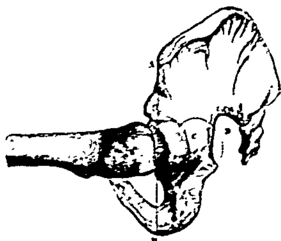


FIG 103 Nelaton's line Reproduced from A Nélaton. "Eléments de Pathologie Chirugicale Paris, 1847

states that when the thigh is flexed to a right-angle and slightly adducte the top of the great trochanter touches this line (Fig. 103). The grea trochanter is displaced above the line when there is an upward dislocatio or subluxation of the hip from whatsoever cause, and often in fracture o the neck of the femur with displacement.

Bryant's triangle was described shortly after Nélaton's line for th express purpose of assisting in the diagnosis of fracture of the neck of th femur, especially impacted fracture. The line AC (Fig. 104) is draw

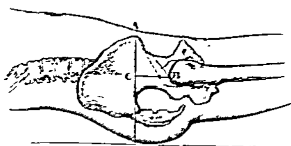


FIG. 104 Bryant s triangle Reproduced from "A Practice of Surgery J & A Churchill. London, 1884

vertically downwards from the anterior superior spine, and the "test lin CB is projected from it at a right-angle to the great trochanter. Brya states that shortening of the "test line" indicates shortening of the neck the femur with precision, and when observed immediately after an injur fracture of the neck is certain. The inaccuracy of this statement is show by his claim that union occurred in forty-two consecutive fractures of t neck diagnosed by this method!

INFANTS

Most infants with hip trouble come under observation because of difficulty in learning to walk, or because of some abnormality in gait, and it is only occasionally that the symptoms are painful or pyrexial. The commoner causes (at the hip) of limp in infancy are: –

In the absence of pain.	Congenital dislocation of the hip.	
In the presence of pain.	Apyrexial	tuberculosis of the hip (or spine).
	Pyrexial	acute suppurative arthritis.

There is no normal age at which a child learns to walk. Individual variation is considerable and walking may begin at any time between about ten months and two years. Delay is not necessarily a sign of physical disease, or even of mental retardation, although either may be present. After walking has started various habits, such as intoeing, not infrequently develop; they are due to temporary difficulty in co-ordination and are more of the nature of postural defects (Chap. I). Recovery can almost be guaranteed once organic disease has been excluded by full and sometimes repeated examination, including radiography, and no treatment is necessary. Spastic paralysis causes difficulty or delay in walking but as a rule it is easily recognized by the characteristic resistance of the muscles to passive movement (Chap. XV).

Congenital dislocation must be diagnosed at the earliest possible moment because the prognosis is largely determined by the age at which treatment is started. The only indication of abnormality may be a slight alteration in shape or symmetry of the limbs, or perhaps a small difference in the range of movements at the hips, and such observations by a mother should never be dismissed merely as worry about her child. Nor should reliance be placed on clinical examination alone because the diagnosis has been missed even by experts—X-rays must always be taken.

The presence of pain either ~~in the hip or referred to the~~ knee together with limitation of movement by muscle spasm is presumptive evidence of tuberculosis. Spinal caries may cause psoas spasm, restriction of movement at the hip and limp, therefore the investigation of limp must include examination of the spine.

ACUTE SUPPURATIVE ARTHRITIS

Acute suppurative arthritis of the hip occurs more frequently in infancy and early childhood than in later years. It may be secondary to sepsis elsewhere, such as impetigo or otitis media, or it may follow pneumonia or one of the exanthemata. The symptoms are those of acute inflammation with abscess formation—sudden onset with high fever and general prostration, local swelling and extreme tenderness. The hip is held flexed and any attempt to move it is violently resented. Occasionally the infection is very mild and is distinguishable from tuberculosis only [illegible]

[illegible] of treatment. The organism is usually [illegible]d therefore be given without delay and

in large doses; for an infant not less than 100,000 units four-hourly for the first forty-eight hours, and then 50,000 units four-hourly for at least a week. Although penicillin has greatly modified the severity of both course and prognosis, it is so important to avoid irreparable damage to the joint that local treatment is also desirable. When the diagnosis has been made within twenty-four hours of onset, the pus is aspirated, penicillin is instilled in its place (p. 418). When treatment is begun later, the joint should be exposed and irrigated; the capsule is then sutured, penicillin is left in the joint, and the superficial layers of the wound are closed. The limb should be fixed in a plaster-of-Paris spica to ensure rest.

Persistent suppuration destroys the articular cartilage and healing then occurs with a fixed joint. Not infrequently, however, the head of the



FIG. 105 Suppurative arthritis of the hip



FIG 106 Suppurative arthritis of the hip at the age of 18 months; successful arthrodesis at five years

femur is entirely destroyed, and sometimes the neck also, leaving an unstable hip (Fig. 105); it is then undesirable to permit weight-bearing or the femur will ride upwards on the ilium causing much shortening. It is difficult, and often impossible, to restore the length of the leg at a later date and therefore the hip should be stabilized as soon as possible. An ilio-femoral arthrodesis should be attempted (Fig .106); the lower end of the graft may not unite, but the upper end will almost certainly fuse with the ilium and form a shelf which prevents upward displacement of the femur. Walking then causes no harm and union of the lower end of the graft can be secured by a further operation at a later date.

CONGENITAL DISLOCATION OF THE HIP

The cause of congenital dislocation of the hip is probably to be found in an error of development in early fœtal life resulting from irregularity of mesodermal division. There is frequently a history of heredity (various authorities give from 15 per cent to 30 per cent), and it is significant that the incidence is greater in some districts, for example in parts of France and Italy, than in others. Females are affected more often than males, the proportion being about seven to one. Unilateral dislocation is somewhat more common than bilateral.

Pathological Anatomy

The acetabulum is usually shallow; the iliac portion in particular fails to develop properly and this makes the acetabulum assume a more oblique position than normal. The head of the femur ossifies late and is displaced upwards and backwards to lie on the dorsum ilii. The joint capsule remains



Fig 107 Congenital dislocation of the hip in a child 23 months of age.

attached at approximately the normal points (the rim of the acetabulum and neck of the femur) and therefore it is elongated. After weight-bearing has commenced the head of the femur slides up the ilium and the capsule is still further stretched and may become thickened. It often happens that folds of the elongated capsule are interposed between the head and the acetabulum thus constituting an obstruction to reduction. The glenoid cartilage and the immediately adjoining part of the capsule are together termed the "limbus" (i.e. region of the border). The upper and posterior segments of the limbus not infrequently are inverted to project into the joint thus preventing reduction (Fig. 112, p. 153). The lower part of the

capsule may also be folded upwards in such a way as to prevent the head from becoming properly bedded in the acetabulum. A ligamentum teres is present in about half the cases; it is often much thicker than normal and contains a large part of the blood supply to the head of the femur.

In the absence of treatment, or when re-dislocation has occurred after attempted reduction, a false acetabulum may develop on the dorsum of the ilium above and behind its proper situation, and although it is shallow, it does give some stability to the joint. The true acetabulum eventually fills with fibro-fatty tissue.

The anteversion of the neck of the femur is increased. Normally the neck of the femur of a baby inclines forwards about 35° and the angle diminishes during growth to the adult angle of about 15°. In congenital dislocation of the hip, the angle at birth is larger than usual and it often fails to diminish during growth. It may be as great as 70° or 80° and then it is a factor of importance because the head of the femur is unable to engage the acetabulum properly and reduction is unstable.

FIG 108 Bilateral congenital dislocation of the hip

Clinical Features

Congenital dislocation of the hip should, in modern conditions, be diagnosed before or very soon after the child has begun to walk. Treatment is then likely to give good results; indeed reduction is only possible during early childhood. It is, however, only comparatively recently that early diagnosis has become common and untreated cases in older children and adults are still encountered.

If the time spent in devising new operations were devoted instead to teaching the early signs to doctors and nurses conducting infant welfare clinics, it would be to the advantage of the patients. It is impossible to exclude the presence of a congenital dislocation, with even reasonable certainty, on the strength of physical examination alone; whenever a suggestive sign is present, and whenever there is a family history of the complaint, the child must be examined radiologically.

Attention may be drawn to the hips before walking commences by some slight asymmetry or shortness of one leg. Often the mother notices a difference in the level of the gluteal folds, or of the creases on the inner sides of the thighs; or, with bilateral dislocation, the space between the thighs may be increased (Fig. 108). All children with a parent or relative, even a distant relative, who was born with a disl[illegible] hip sho[illegible]

X-rayed when a few months of age. Routine X-ray examination of all babies is practised in areas where congenital dislocation is endemic.

LIMP is usually the first abnormality to be noticed after the child has begun to walk. The limp is of the Trendelenburg type but it is easily overlooked when the dislocation is bilateral. Lordosis is marked because the head of the femur, in its abnormal position, is situated behind the centre of gravity and the body weight rotates the pelvis forwards.

TRENDELENBURG'S SIGN is always positive (p. 144). It can be elicited in an infant by getting her to climb on to her mother's knee. If she tilts the pelvis upwards as she lifts her leg, it is unlikely that she has a dislocation of the hip of the side on which she is standing.

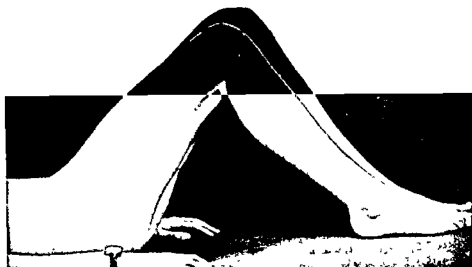


FIG 109 Shortening of the femur

REAL SHORTENING of the leg is always present and amounts to about alf an inch to one inch. The shortening is in the thigh and is demonstrated hen the child lies on her back with hips and knees flexed and feet flat on he couch; the upper end of the tibia on the affected side is then more roximal than that on the sound side (Fig. 109).

PALPATION of the head of the femur in an abnormal position is the nost definite clinical finding. The head is apparent as a fullness on the lorsum ilii, and it can be felt to move when the hip is partly flexed and otated from side to side.

TELESCOPIC MOVEMENT is sometimes present because of lack of upport for the femoral head. It is demonstrated whilst the hip is partly lexed by pushing and pulling the leg in the longitudinal axis of the thigh.

X-rays. Interpretation may be difficult before weight-bearing has ommenced. The chief points are :—

1. The head of the femur is always displaced upwards although the displacement may at first be so slight as to escape casual notice. Normally the upper border of the head is opposite the Y cartilage of the acetabulum.

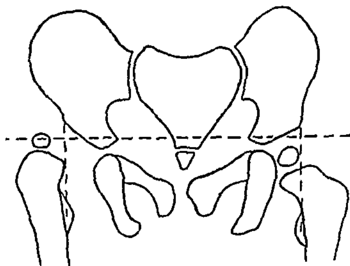


FIG 110. Perkins' square.

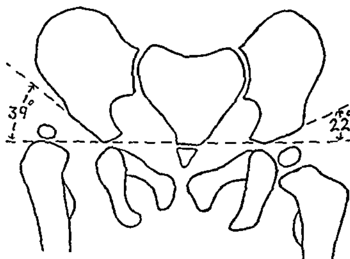


FIG 111 Acetabular angle

2. The head of the femur should lie within the angle formed by th horizontal line passing through the top of the "Y" cartilage an the perpendicular dropped from the outer angle of the acetabulu (Perkins' square, Fig. 110).
3. Ossification of the femoral head is delayed.
4. The acetabulum is poorly developed, more so sometimes than other The development of the acetabular roof is of prognostic importanc The angle formed between the horizontal and the plane of t upper half of the acetabulum is normally about 22°.; it is increas in congenital dislocation, usually to between 30° and 40° (Fig. 11 The nearer the angle to normal, the more likely is reduction to stable.
5. Increase in anteversion of the neck of the femur shows as fo shortening, and when it is marked the neck and shaft lie almost the same plane.

Arthrography is indispensible as a means of determining the arrangement of the soft tissues surrounding the joint and whether there is any obstruction to reduction. It is usually carried out under general anæsthesia. A needle is introduced into the joint by a lateral approach and 2 to 4 cc's of diodone, or a similar absorbable radio-opaque fluid, are injected.

Interpretation of the X-rays requires experience. A thin film of fluid outlines the head of the femur, and this seems surprisingly large when compared with the ossific centre, which is all that is seen of the head in ordinary X-rays. There is a line of fluid around the neck of the femur, and a pool in such part of the acetabulum as is unoccupied by soft tissues.

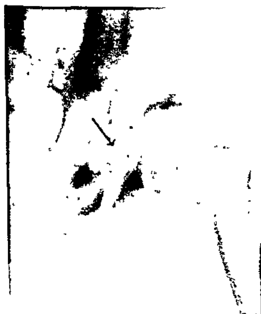


Fig 112 Congenital dislocation of the hip The arthogram, made after an unsuccessful attempt at reduction by divarication, shows a large inverted limbus (arrow)



Fig 113 Congenital dislocation of the hip The arthogram shows a so-called "hour-glass constriction", but at operation the chief obstruction to reduction was found to be the inverted limbus (arrow)

When, as not infrequently happens, the limbus is inverted, it shows as an indentation projecting into the upper part of the mass of opaque fluid lying between the head and the acetabulum (Fig. 112). When the lower part of the capsule is also folded upwards, the resulting appearance is often referred to as an "hour-glass constriction", but the description is not accurate because there is no true constriction of the capsule, only an infolding (Fig. 113).

Prognosis

Treatment is so lengthy and arduous an affair, sometimes involving more than one operation, that it is important to have an idea both of the natural history of the complaint in the absence of treatment, and of the results of treatment.

An unreduced dislocation is a handicap in that the gait may be ungainly, and it interferes with athletic prowess. It does not, however,

prevent most occupations from being followed, and many of the women are married. Pain is unusual before the age of twenty-five or thirty, and very many retain useful, painless hips throughout life. When there is pain it is more often in the back and associated with lordosis, than in the hip

The most perfect reduction with a nearly normal radiological appearance does not give a normal hip. The function may well be perfect for thirty or forty years but after that time, almost invariably before the age of fifty, osteoarthritis develops. Reduction does not, of course, reduce the risk of transmitting the deformity to the next generation.

Operations for reconstruction after unsuccessful reduction, or when the acetabulum has not developed properly, have not given more than fifty per cent of successful results, and even these will probably become painful later in life.

It seems, therefore, that reduction should always be attempted because, when successful, it will enable the patient to lead a normal life until middle age. Reconstruction operations are less obvious in their advantages and the pros and cons require careful consideration for each individual.

Treatment

Successful treatment is possible only in infants, preferably before beginning to walk. The prognosis becomes progressively worse with increasing age until, after five or six years, it is doubtful if surgery gives any lasting benefit.

In infants the aims of treatment are *firstly* to place the head of the femur in the acetabulum without interposition of soft tissues, and *secondly*, to keep it there until both acetabulum and head of femur have developed properly. The earlier reduction is effected, the more likely is the second objective to be achieved. Closed reduction is undoubtedly best, but it is not always successful. The present tendency is to perform an open reduction as soon as it has been shown that closed reduction is impossible. Reconstructive operations are also performed early, when it is clear that development is not taking place naturally and the hip is going to be unstable.

Arthrography makes it possible to determine the cause of imperfect reduction, and often to recognise in advance those occasions on which closed reduction is unlikely to be successful (Figs. 112 and 113). It is now a routine procedure, and usually performed under general anæsthesia.

Closed Reduction. This is the treatment of choice and it is successful in a large proportion of infants. Manipulative reduction, introduced by Lorenz at the end of the last century (the bloodless operation of Lorenz), was a great advance on previous methods. However, it entails some trauma to the head of the femur, especially if roughly performed: the effect may be to cause an osteochondritis of a type resembling Perthes disease, and the prognosis is adversely affected. Reduction by gradual abduction of the hips (divarication) is without trauma and has greatly reduced the incidence of osteochondritis.

A preliminary arthrogram is desirable, except perhaps in children who have not walked, to make sure that there is no obstruction to reduction. Arthrography is necessary after reduction to confirm that no soft tissues are interposed between the head of the femur and the acetabulum.

After reduction, immobilization is continued until the acetabulum and femur have developed properly and the joint is stable. If it is clear that this is not going to take place, a reconstructive operation may be considered.

Divarication. Forrester-Brown's modification of Putti's divaricator is a convenient apparatus (Fig. 114). The legs are gradually abducted

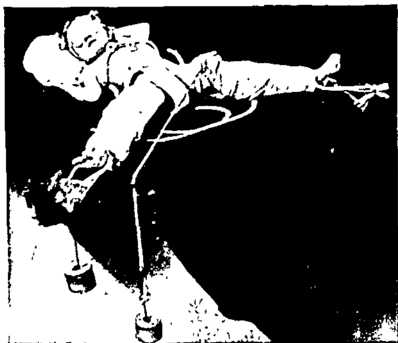


Fig. 114 Reduction of congenital dislocation of the hip by gradual abduction Note the lateral pull applied to the left leg

during a period of two or three weeks until nearly in a straight line with each other. The apparatus is then changed for a plaster cast or simple metal splint. Reduction is confirmed by arthrography, and subsequent progress is controlled by plain X-rays. Full abduction is maintained for about six months and then decreased, as described for the later stages after manipulative reduction.

Manipulative Reduction is necessary in children over about two years of age, and occasionally when divarication has failed. The difficulty increases with age because the muscles and fascia are contracted, the joint capsule is thickened, and there are changes in the acetabulum. Reduction is likely to be impossible or accompanied by excessive trauma after six years of age when the dislocation is unilateral, and after four years when it is bilateral. The method of manipulation is to exert traction on the flexed and abducted thigh and lever the head over the rim of the acetabulum. Alternatively it can be performed with the patient lying prone.

After reduction, the hips are fixed in a double plaster-of-Paris spica; the plaster extends to the ankle of the affected leg or legs, but stops above the knee of a sound leg. The position of fixation should be that in which the hip feels most stable. In the *Lorenz* position, there is 90° flexion, 90° abduction and 90° external rotation; the patellæ face upwards and outward and the thighs and legs are in the coronal plane (Fig. 115).

Immobilization is continued until X-rays show that the acetabulum is developing and there is every prospect of the hip being stable; this usually takes from nine to eighteen months. The plaster requires changing



FIG 115 The Lorenz position

every three months, or more frequently if badly soiled. It is advisable to reduce the amount of flexion and abduction after nine months, if it can then be done without interfering with stability. The final plaster may be in 30° of flexion, 30° of abduction and neutral rotation, a position which permits walking whilst preventing re-dislocation. Towards the end of the period of fixation the plaster is split and the child removed once or twice a day for massage and exercises. The range of movements is allowed to increase under supervision until finally the plaster is omitted entirely. It takes at least a year after leaving off the plaster for walking to become normal. The *Batchelor* type of plaster which maintains abduction and rotation whilst permitting active flexion is useful in the later stages (Fig. 116).

Nursing a child in a plaster spica requires some ingenuity. Napkins can be avoided by keeping the child raised on pillows and leaving a receiver beneath her; or a board may be fixed in the cot at an incline and the plaster tied to it without the child feeling that she is being restrained. Older children are often happier lying face downwards during part of the day because it is then easier to look around and play; they propel themselves about the floor with hands and elbows in an astonishing fashion, and even walk if given the chance.

Operation. No operation should be performed immediately after a long period of immobilization because this may lead to intractible stiffness of the hip, a distressing occurrence when the leg is fixed in a position of abduction and rotation. It is safer to postpone operation for a time while free active movements are permitted.

OPEN REDUCTION is indicated when the arthrogram shows that there is an obstruction to reduction, or that soft tissues are interposed between the femoral head and the acetabulum. It should be carried out at as young



FIG 116 Batchelor's plaster

an age as possible, preferably under two, although an occasional good result is obtained as late as six or seven years.

Operation should only be attempted by a surgeon with special experience in this class of work. A few days should first be spent in bringing the head of the femur down to the level of the acetabulum by divarication or traction. The hip is then exposed and the obstruction to reduction removed. It is usually sufficient to excise the inverted limbus at the upper and posterior aspects of the joint (Fig. 112, p. 153). It is seldom necessary, in infants, to interfere with the inside of the acetabulum, and the ligamentum teres should, if possible, be left intact. It is sometimes advisable to perform a reconstruction at the same time as an open reduction. After reduction the leg is fixed in a plaster spica in about 45° of abduction and full internal rotation.

RECONSTRUCTION. This operation is designed to lower the upper lip of the acetabulum when it fails to develop properly. It is often advised after closed or open reduction when acetabular development remains poor, and in the event of re-dislocation even a considerable time after reduction. The decision to operate is not, however, an easy one to make and it depends to no small extent on the surgeon's own views as to the prognosis and his general outlook on life. The longer the follow-up he has studied, the less impressed he will be by the value of operations of this type.

The operation is conveniently performed through a window cut in a previously applied plaster spica. It consists in depressing the roof of the acetabulum and turning down a flap of the outer table of the ilium above the acetabulum ; the gap is filled with a graft cut from the ilium (Fig. 117) Consolidation is rapid and weight-bearing can usually be commenced after three months.

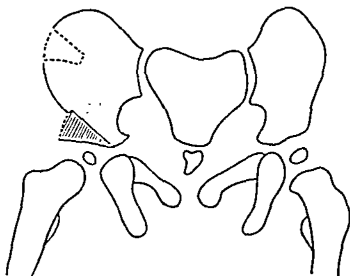


Fig 117 Reconstruction of upper lip of the acetabulum

Rotation Osteotomy. The question of excessive anteversion of the neck of the femur should be considered before deciding on a reconstruction operation. When the neck of the femur points almost forwards, the head is able to engage the acetabulum only whilst the leg is rotated inwards; in these circumstances an osteotomy is performed just below the lesser trochanter and the leg is externally rotated the required amount.

Adults

Dislocation Reduced. Successful reduction in early childhood followed by good development of the acetabulum gives excellent function for many years, but it is now apparent that these hips usually, if not invariably, wear out by middle age and become osteoarthritic. Osteoarthritis develops earlier when there has been osteochondritis and the head of the femur is deformed. The condition follows the same course as with osteoarthritis due to other causes and requires managing in the same way (p. 178). The pain often becomes severe enough to demand relief by arthrodesis or arthroplasty.

Dislocation *not* Reduced. Many people go through life without serious symptoms, but a number develop pain in either the hip or the low back.

A false joint on the dorsum ilii does not often become osteoarthritic because it is so very shallow, but pain is sometimes caused by the excessive strain on the capsule and ligaments. A young adult can often be helped by some form of reconstructive operation. The head of the femur is first pulled down as far as possible by traction continued for some weeks and then kept in position by massive bone grafts placed abo... ...d behind it

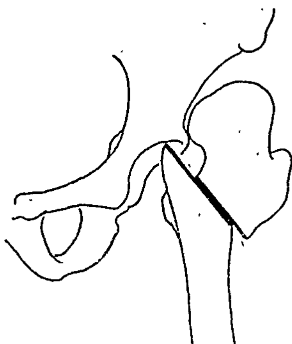


Fig. 118 Lorenz bifurcation osteotomy

perhaps with the intervention of a vitallium cup (Fig. 119). Older people do not re-adjust well after so extensive a procedure, but the simpler, Lorenz bifurcation osteotomy may be worth a trial (Fig. 118).

Low back pain is a more frequent cause of complaint since the lordosis, which always accompanies an unreduced dislocation, places the spine at a considerable mechanical disadvantage. It is difficult to treat because, for a lasting result, it is necessary to alter the line of transmission of body weight in such a way that the pelvis is rotated backwards and the lordosis reduced. Bifurcation osteotomy does to some extent have this effect, but the operation is not an unqualified success.



Fig. 119 Unreduced congenital dislocation in a girl aged 26 with severe pain at the hip A new acetabulum was constructed and five years later she was still glad she had had the operation

CONGENITAL COXA VARA

This is a rare condition in which there is a congenital defect in development of the neck of the femur. A number of variations have been described, but Campbell Golding has been able to follow the X-ray changes in several patients throughout the period of growth and has shown that most of them, and also micromelia due to a short femur, are really different degrees and different stages of the same condition (Fig. 120).

The only available treatment is to restore the angle of the neck by an abduction, sub-trochanteric osteotomy. This not only corrects the deformity but also promotes rapid ossification of the gap in the neck.



FIG 120 Congenital coxa vara and short femur (By kind permission of Dr. Campbell Golding and the Editor, *Journal of Bone and Joint Surgery*)

The radiographic features, not all of which are present in every case, are given below (Golding) :—

1. An oblique or vertical defect in the neck which gives the appearance of cutting off a triangular fragment from the antero-inferior angle. There may be a second triangular fragment at the antero-superior angle.
2. A varus deformity.
3. A short neck.
4. A fragmented neck.
5. Delay in ossification of the neck and upper part of the shaft.
6. Incomplete ossification of part of the neck.
7. Beaking of the great trochanter.
8. A facet formed on the ilium by the abnormal trochanter.
9. Secondary deformity of the acetabulum due to the malposed head.
10. Shortening of the shaft of the femur.

CHILDREN AND ADOLESCENTS

Transient synovitis	all ages	maximum	2-7	years
Tuberculosis	all ages	,,	2-7	,,
Perthes disease	3-16 years	,,	4-9	,,
Adolescent coxa vara	8-19 years	,,	12-15	,,

The early symptoms of disease of the hip of whatsoever nature are pain and limp. Every child with these symptoms must undergo a thorough clinical examination and if there are any positive findings, he must be X-rayed. The early physical signs are limitation of movement of the hip, and spasm of one or more of the muscles controlling the hip, or spasm of the anterior abdominal muscles (p. 144). *The limitation of movement may be slight and the spasm unobtrusive* so considerable care may be needed to demonstrate them.

The symptoms are transient in a large majority of children, but it is impossible to be sure that they are transient until they have gone. It cannot be emphasised too strongly that every child with symptoms or physical signs at the hip must be regarded as suffering from serious organic disease until the contrary is proved. The early symptoms and signs are identical in transient synovitis, tuberculosis, Perthes disease, and adolescent coxa vara. In all these conditions, except perhaps adolescent coxa vara, radiological examination at an early stage is negative, and it is only when treatment is begun early that the best results can be hoped for. Every child with symptoms at the hip must, therefore, be treated as if the disease were serious, whether or no the X-rays are normal, and even though time will usually show that the parents have been needlessly alarmed.

TRANSIENT SYNOVITIS

Symptoms at the hip are due, in at least four children out of five, to a simple synovitis, perhaps resulting from a minor injury such as a sprain. The reaction of the hip to minor injury is the same as elsewhere but it is less readily appreciated because the joint is deep seated and is not readily examined by palpation. The only physical signs are limitation of movement and muscle spasm, and there is no swelling or localized tenderness. Radiological examination is negative and a positive diagnosis is impossible.

Treatment. Although the nature of the disease is not known, the worst must be assumed and the child put to bed immediately. It is advisable to apply extension to the limb but no elaborate apparatus is necessary; a five pound weight attached to the leg by adhesive strapping and hung over the foot of the bed is sufficient. The majority of patients with only simple synovitis will be free of signs after ten to fourteen days and may then be allowed to get up. They are re-examined after a further fourteen days and if there are still no signs of disease, it can be said with some assurance that none is present. If any signs or symptoms persist, the cause will soon be revealed radiologically.

TUBERCULOSIS OF THE HIP

Tuberculosis of the hip is essentially a disease of childhood. Nine out of ten cases occur during the first decade of life, and about half of these between three and five years of age. Males are affected slightly more frequently than females.

The infection, as with all tuberculosis of bone, is invariably secondary to a primary site elsewhere in the body. The common starting points in the hip are shown in order of frequency in Fig. 121. The initial focus enlarges and quickly spreads to the joint, involving first the synovial membrane and then the adjoining surfaces of the acetabulum and head of the femur. Soon the whole joint is destroyed and replaced by tuberculous granulation tissue.

The course of the disease is modified by chemotherapy, and when the infection is mainly synovial, the joint is sometimes restored almost to normal. In less favourable circumstances, the amount of destruction of bone is reduced and secondary infection is prevented.

Healing is by fibrous replacement of the tuberculous tissue and this, when there has been gross destruction of bone, results in fibrous ankylosis. Although the fibrous tissue is strong, it may yield gradually with the passing of years and permit the return of deformity. Moreover, small foci of living tubercle bacilli are sometimes encapsulated in the fibrous tissue where they remain as a permanent menace and therefore the hip cannot be regarded as secure unless there is bony ankylosis [illegible] ...ly in the absence of secondary infectı[illegible]

FIG 121 The starting points in tuberculosis of the hip (Reproduced from "Recent Advances in Orthopaedic Surgery" by permission of Mr B H Burns and Mr V H Ellis)

The disease may remain [illegible] the base of the neck of the femur (Fig 322, p 430), and also occasionally in metaphysial infection The response to excision of the focus combined with chemotherapy is good, but general treatment must be continued until the outcome is certain.

Signs and Symptoms

Early. LIMP and PAIN are the important early symptoms, limp as a rule being the more significant. The onset is insidious; at first there may be nothing but a limp which is present only when the child is tired and disappears after rest. Later the limp becomes constant, and some aching at the hip and general fatigue may be noticeable. Pain is seldom prominent and it is felt as often at the front of the thigh and [illegible] of the [illegible]

at the hip. On examination, there is usually a little restriction of movement in every direction, and possibly tenderness over the joint. The hip ay b

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id effusion, but before the disease has invaded the joint. This is e time to commence treatment, therefore every child limping without bvious cause must have the hips (and back) examined; if there is any nderness, limitation of movement or spasm, and even if X-rays are egative, that child must at once be put to bed.

Intermediate. As the disease progresses nd there is more extensive involvement of the oint, *muscle spasm* and *deformity* become e prominent features. On examination, there muscle spasm induced by any attempt to orce movement, and obvious limitation of novement in every direction. Gauvain's sign p. 144) is almost always positive. There may e a little muscle wasting. Deformity is caused y spasm which draws the hip into a position f flexion, adduction and internal rotation, thus roducing the classical posture of the tuberculous hip—apparent shortening and lordosis. Thomas's test (p. 144) confirms the presence nd extent of flexion deformity.



FIG 122 Early tuberculosis of the hip Note the flexion deformity and compensatory lordosis

Late. *Gross wasting*, *swelling* of the oint and *real shortening* are late signs which nly become apparent when bone destruction is dvanced. Wasting affects all the muscles of the imb but is more marked in the thigh and buttock than in the calf. Swelling is due to distension of the joint with tuberculous material. Real shortening occurs when there is gross destruction of the head of the femur and acetabulum, and when the joint is dislocated.

Abscess formation, which occurs in about 50 per cent of all patients, is the result of perforation of the joint capsule by tuberculous material. The abscess may present at the surface anteriorly between the sartorius and tensor fascia femoris, or pass internally between the adductor muscles; it may also collect deep to the glutei, and occasionally it perforates the acetabulum to form an intra-pelvic abscess.

X-ray Appearances. At a very early stage the joint space may be slightly increased by effusion, but there is no alteration in the structure of the bone. After involvement of the joint, the articular cartilage is eroded and the joint surfaces of the bones are attacked by the disease; the cardinal features are then :—

1. Narrowing of the joint space.
2. The outline of the bone loses sharpness and becomes indefinite.
3. Rarefaction of all the bones for some centimetres around the joi

As destruction of bone proceeds, the trabecular structure is lost a cavities appear and later coalesce (Fig. 123). The extent of irreparable bo destruction varies; it may be negligible or there may be virtual destructi of the whole head of the femur and acetabulum. When there has be inadequate protection from muscular spasm, pressure of the head of t femur on the softened acetabulum causes it to travel upwards and bac wards (wandering acetabulum) and finally the head may dislocate on the dorsum ilii.

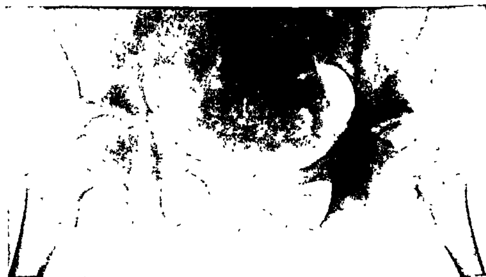


FIG 123 Tuberculosis of the hip.

Treatment

Conservative. GENERAL TREATMENT to increase resistance to t infection is essential and it is now almost universally carried out at open-air hospital. Chemotherapy is of considerable benefit. It h reduced the duration of conservative treatment by perhaps a half, a many children are now able to leave hospital after twelve to eighte months. Healing with a movable joint has become more common. a the range of movement is often excellent.

LOCAL TREATMENT is directed towards minimizing the amount of bo destruction and assisting resolution to take place without deformi During the stage of active bone destruction, extension is applied to t limb in order to provide rest, relieve pain and spasm, correct deformi and prevent distortion of the acetabulum by pressure of the head of t femur. During the stage of resolution, extension is replaced by a plas spica which permits the joint surfaces to come together, and allows fibro ankylosis to take place in the best position.

The method of applying extension varies with the hospital. T

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easy nurs ... to detect abscess ... it is

enough to carry although movement to and from the open-air is simplified when the frame is mounted on a trolley.

Prolonged immobilization, particularly by traction or an abduction frame, has the grave disadvantage that it is frequently followed by premature fusion of the epiphyses at the knee. The bone becomes porotic and the epiphysial discs, lacking proper support, first bulge towards the corresponding metaphyses and then rupture. Either the lower femoral or upper tibial epiphysis, or both, may be affected and the result is to shorten the limb to an extent depending on the age at the time. Premature fusion occurs only after immobilization for at least two years and every endeavour must be made to keep the time shorter.

Immobilization is continued until the radiographs, which are taken at three monthly intervals, show that bone destruction has ceased. A double



Fig 124. Tuberculosis of the hip treated on a double abduction frame (Royal National Orthopædic Hospital, by courtesy of Mr H J Seddon)

plaster spica is then applied to include the whole leg on the affected side and the other thigh. The plaster is bivalved to permit regular inspection of the joint. The patient is kept in plaster until the disease is quiescent and recalcification well advanced. Weight-bearing is then permitted in some sort of protective apparatus, usually a spica including the affected limb only. Protection is continued until there is no longer any tendency to deformity, preferably until after there is bony ankylosis, spontaneous or operative. In a small number of patients the disease is mainly synovial; there is little destruction of bone, healing occurs without ankylosis and a useful range of movements is regained after all apparatus has been discarded.

A sinus gravely affects the prognosis because of the risk of secondary infection. Every care must be taken, therefore, to detect and treat an abscess immediately it forms and prevent it bursting. The method of choice is by aspiration repeated as often as may be necessary.

Operative. Disease Active. Operation has not yet gained a place in the routine treatment of active disease, but it is now practised more frequently. Surgical evacuation of an abscess, perhaps combined with the removal of sequestra, may be helpful when an excessive quantity of pus is produced; the wound is closed, and, with the aid of chemotherapy, it usually heals by first intention and remains healed.

When bone destruction has ceased but the commencement of resolution is delayed, when progress is "hanging fire", there may be a favourable

reaction to almost any operation in the region of the hip; even a subtrochanteric osteotomy is followed not infrequently by spontaneous bony ankylosis.

DISEASE QUIESCENT. When the disease has healed with fibrous ankylosis, arthrodesis is the only form of permanent protection for the joint, and the best insurance against re-activation. It is commonly delayed until after twelve years of age because of the difficulty in obtaining fusion when younger.

Arthrodesis in tuberculosis is usually performed by an extra-articular route to avoid entering a potentially infected area. There are two methods :—

(*a*) *Ilio-femoral Arthrodesis.* A strut of bone cut from the ilium or the tibia is placed between the great trochanter and the ilium immediately above the acetabulum (Fig. 125). Fusion occurs with some certainty at the

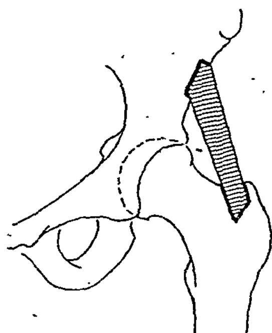


FIG 125 Ilio-femoral arthrodesis

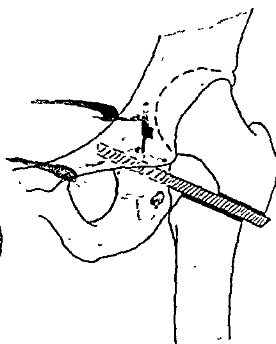


FIG 126 Ischio-femoral arthrodesis (Brittain).

upper end of the graft, but union at the lower end is frequently delayed or prevented by the tendency of the hip to flex and adduct thus separating the graft and the great trochanter. This operation, in most clinics, has been superseded by:

(*b*) *Ischio-femoral Arthrodesis* (Brittain). A massive graft from the tibia is passed through a gap cut in the femur by subtrochanteric osteotomy and embedded in a notch made in the ischium (Fig. 126). Union takes four to five months but is very strong. This method may be employed in adults before the disease is completely quiescent because it does not prevent the upward thrust of the femur which is desirable to obliterate potential spaces where the bone has been destroyed (Fig. 323, p. 432).

PERTHES DISEASE

(*Synonyms*) Pseudocoxalgia, Calvé-Legg-Perthes disease, coxa plana, osteochondritis deformans juvenilis, quiet hip disease.

Perthes disease of the hip is usually included in the group of affections of the epiphyses and small bones known as *osteochondritis juvenilis.* The commoner are Schlatter's disease of the tubercle of the tibia, Köhler's disease of the tarsal scaphoid, Sever's disease of the apophysis of the os calcis, and Freiberg's disease of the metatarsal heads, but changes of similar type have been described in many other bones.

The ætiology is obscure and in spite of much experimental work no acceptable conclusion has been reached. The theory most favoured at present is that a vascular disturbance, possibly due to trauma, causes ischæmic necrosis.

The affection appears to run a definite course lasting from one to three years, which can conveniently be divided into three stages—onset, activity and healing (Platt). The initial stages are degenerative with necrosis of the bony trabeculæ which break up into small fragments; the marrow spaces are filled with necrotic marrow and fragments of dead bone. The unossified cartilage is but slightly affected, and arthrograms show that there is surprisingly little alteration in the true shape of the head until quite late in the course of the disease. During the stage of repair, the blood supply increases, necrotic debris is removed and new bone is laid down.

Clinical Features

The onset may be at any age from four to sixteen years with a maximum incidence from four to nine years. The disease is two or three times as common in boys as in girls and it is usually unilateral although bilateral involvement is not uncommon.

The Stage of Onset is clinically indistinguishable from tuberculosis. The first complaint is usually of limp, and although pain may be present it is not a marked feature. Examination shows muscular spasm and limitation of [illegible] often more marked [illegible] limitation of move[illegible] disappear rapidly with rest but return if weight-bearing is resumed.

The Stage of Activity follows rapidly and lasts for about two years. On examination during treatment there may be a complete absence of abnormal physical signs, nevertheless treatment must b continued for as long as X-rays show the bone to be soft. At the conclusion of the stage of healing, it will almost always be found that the clinical findings are more favourable than the X-ray appearance suggests they should be; there is seldom pain or limp and the range of movements is good. The ultimate prognosis, however, does not depend on the immediate clinical findings, and unless the shape of the hip is all but perfect, osteoarthritic changes are bound to occur sooner or later.

Stage of Healing. The epiphysis commences to regenerate and the structure of the bone slowly returns to normal. The head of the femur

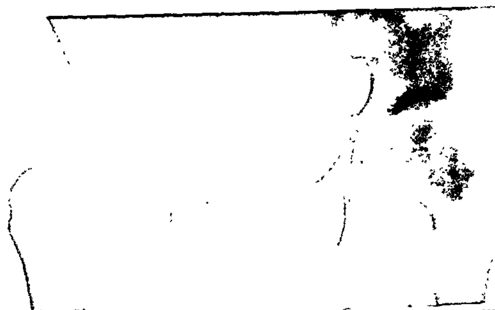


Fig. 127. Perthes disease at a fairly early stage showing an apparent increase in joint space and fragmentation of the epiphysis

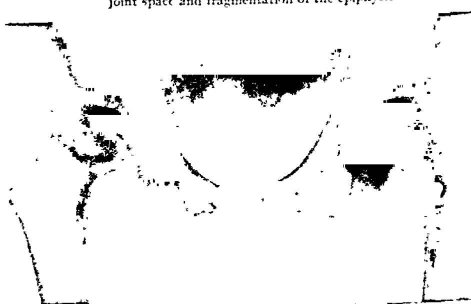


Fig. 128. Perthes disease with marked changes in the metaphysis

seldom retains its normal shape and the acetabulum adapts itself to any alteration; at best, the head is a little broader than normal, and at worst it is compressed into the mushroom shape of the classical descriptions of the [illegible] ned. [illegible] pse. [illegible] read [illegible] plied [illegible] ead. [illegible] thes In norm[illegible] disease it may be as small as twenty.

X-rays (Figs. 127 and 128). The earliest changes (*stage of onset*) are :—

1. Apparent increase in size of joint space.
2. Increased density of the epiphysis.



FIG 129 Untreated Perthes disease

The classical appearance develops later (*stage of activity*).

3. Fragmentation and condensation of the epiphysis.
4. Metaphysial rarefaction giving an appearance of cavitation, often most marked at the inner end of the epiphysial line.
5. Obliteration of trabeculæ in the subchondral area.
6. Flattening and mushrooming of the epiphysis.
7. Broadening of the neck of the femur.

Treatment

The immediate good results following any treatment, or no treatment at all, have in the past tempted surgeons to be unjustifiably optimistic. The late results are, however, so deplorable that an attempt must be made to preserve the shape of the head whenever a preliminary arthrogram shows its cartilaginous outline to be nearly normal.

The ambulant methods often practised do not give complete relief from pressure and nothing less will suffice to protect the head. It is essential to maintain recumbency, and to hold apart the surfaces of the joint by continuous traction. Fixed traction on a frame as in tuberculosis may be used, but weight traction with the leg supported on a counterbalanced Thomas's splint is probably adequate and gives the patient a more tolerable existence.

Treatment must be continued until the stage of activity is complete and healing has advanced to a point at which the bone is strong enough to take pressure without being distorted. No method is known that will reduce the time taken by the disease to run its course, nor is there any method of restoring the shape of the head of the femur to normal after it has been deformed. The only hope of complete success is to make the diagnosis before there is any serious change in shape and then to prevent such a change occurring. Two years or more may seem a long time in hospital for a child suffering from a disease that does not endanger life, but the reward of a sound hip may make it worth while.

ADOLESCENT COXA VARA

(*Synonym*) Slipped femoral epiphysis

There are several causes of varus deformity of the neck of the femur:—

1. Adolescent coxa vara.
2. Fracture of the neck of the femur, usually a basal fracture, permitted to unite without proper reduction, or to bend because weight-bearing has been commenced too early.
3. Metabolic diseases such as rickets and osteomalacia causing softening of the bone severe enough for it to bend under the weight of the body (p. 181).
4. Congenital coxa vara (p. 160).

Adolescent coxa vara is a condition in which the upper femoral metaphysis is in an abnormal state which renders the epiphysis liable to displacement. The name is derived from the deformity which occurs in the



FIG 130 Adolescent Coxa Vara with gross displacement

majority of patients, but deformity is not an inevitable sequel. Displacement is often gradual, sometimes it is bilateral, and very occasionally there is simultaneous separation of other epiphyses. The disease can occur at any time between eight and nineteen years of age but it is commonest between twelve and fifteen, and it is seen much more frequently in boys than in girls.

The pathology is not understood but it may be significant that most cases occur in the same physical type—fat children, many with a definite Fröhlich syndrome. Trauma often plays a part but its relation to the onset of symptoms is variable. Frequently no history of injury can be obtained; sometimes an injury, usually comparatively trivial, precedes the onset of symptoms by days or weeks ; at other times trauma occurs after symptoms have been present for some weeks and causes a sudden exacerbation.

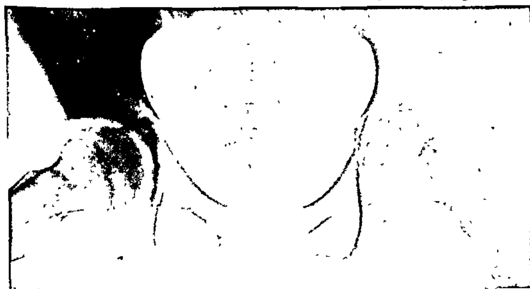
Clinical Features

There are three distinct stages :—

STAGE 1. *Before there is any slipping, or whilst it remains minimal.* It is probable that symptoms do not occur until after slipping has commenced. The earliest displacement is rotation ; this is not easily detected in antero-posterior radiographs and may therefore be missed, but it is obvious in lateral views (Fig. 131).

Pain is the outstanding symptom and usually the first to be noticed ; it commences gradually and is often referred to the inner side of the knee. Limp due to muscle spasm develops as the pain increases. On examination the only findings are muscle spasm and slight limitation of abduction. The stage of minimal slipping may last for some weeks and, if treatment is begun in time, further slipping can be prevented.

STAGE 2. *After gross slipping has taken place.* The patient may first come under observation after gross slipping has taken place. Sometimes this occurs gradually, but sometimes it happens suddenly, either with or without trauma. The direction of displacement is such that the neck of the femur moves upwards in relation to the head, and it also rotates so that the epiphysial surface of the neck faces forwards and upwards (Fig. 130).



IG 131 Adolescent Coxa Vara Stage 1, lateral view There was no visible displacement in the antero-posterior view although metaphysial changes were shown

Pain is usually greater than during the first stage; limp also is ncreased and is due to deformity as well as to spasm. There is an adducion—external rotation deformity and the limb cannot be abducted or nternally rotated. There is apparent shortening to compensate for the

limp and deformity remain. Osteoarthritis is the inevitable sequel of deformity and the late prognosis is bad unless displacement is arrested during the first stage, or unless a good reduction is obtained without trauma.

X-rays (Figs. 130, 131 and 132). During the first stage slipping may not be apparent in antero-posterior films although lateral views show slight external rotation of the neck in relation to the head. After the typical deformity has developed, the neck is displaced upwards and rotated outwards and upwards, the lower margin of the neck perhaps lying opposite the centre of the head.

There is always some change in the structure of the metaphysis which may be slight or may be marked. In a severe case there is a band about 1 cm. wide in which the bone is rarefied and there may be areas of trabecular absorption giving almost a cystic appearance. The neck often becomes rather broader and shorter.

Shenton's line is a useful guide to upward displacement of the neck of the femur. Normally the curve of the upper border of the obturator foramen is continuous with that of the lower border of the neck, but this line is broken when the neck is displaced.

Treatment

Every child with symptoms directed to the hip, that is every child complaining of pain or limp, should be put to bed with extension applied to the limb until a diagnosis is made. This is the treatment of the first stage of adolescent coxa vara, and of Perthes disease, and it is a good start with the treatment of tuberculosis.

STAGE 1. Reduction is unnecessary when diagnosis is early and there is only minimal slipping, but further displacement must be prevented. The most satisfactory way of doing this is to insert a tri-fin nail using the same technique as when operating for a fracture of the neck of the femur. A normal life is resumed as soon as the wound has healed.

When operation is contra-indicated extension is applied with 5–10 lbs weight, the limb being supported on a counter-balanced Thomas's splint. Extension must be maintained until the metaphysis has regained it normal structure; sometimes this takes no more than three months, bu nine to twelve months may be required.

STAGE 2. Treatment is more uncertain because although reduction o the displacement is desirable, it may be difficult or impossible. Forcibl reduction by manipulation is frequently followed by permanent stiffness c the hip and it is unwise to attempt it. Skeletal traction with 30–40 lb weight applied to a pin or wire through the tibia is occasionally successfu The maximum weight should be continued for a month after reduction i obtained and then it may be reduced to a few pounds until the X-rays sho satisfactory healing. Or alternatively reduction may be retained wit certainty by introducing a tri-fin nail.

When skeletal traction fails to reduce the displacement within a wee or so, operative correction is desirable. The adduction deformity, if le uncorrected, causes considerable disability because of the compensator

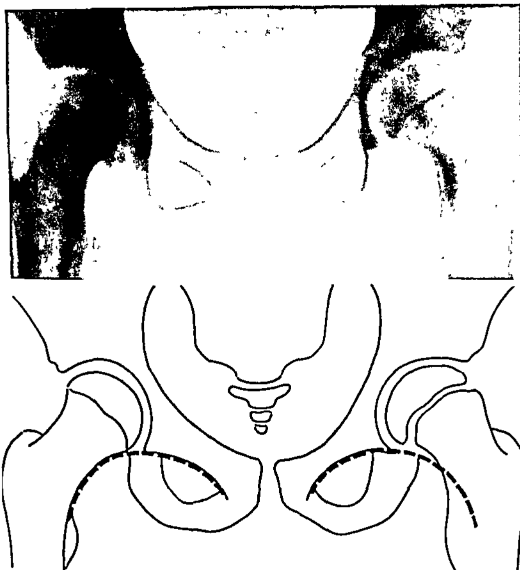


Fig 132 Adolescent Coxa Vara with displacement visible in the antero-posterior view. The diagram shows Shenton's line

pparent shortening; and in addition, the head of the femur is rotated ito an unnatural position in the acetabulum so that the joint surfaces are o longer congruous and osteoarthritis quickly develops.

There are three possible operations; the epiphysis may be replaced in the right position, or the deformity may be corrected by transcervical r by subtrochanteric osteotomy. The first two have the drawback that hey interfere with the blood supply of the head and may cause osteochondritis to develop. Sub-trochanteric osteotomy is a simple procedure which both corrects the deformity and rotates the head into its proper position in the acetabulum. Whichever operation is selected, it should be carried out as soon as possible to prevent reactive changes in the joint.

Stage 3. Reduction is clearly impossible, but if there is an adduction deformity it should be corrected by sub-trochanteric osteotomy. Osteoarthritis is the common sequel and it should be treated along the usual lines (p. 178); since it often develops at so young an age, arthrodesis is likely to be the best procedure.

ADULTS

RHEUMATOID ARTHRITIS

Arthritis of the rheumatoid type occurring at the hip is almost always part of a generalized arthritis. It occurs at any age from childhood (Still's disease) to late middle-age and its general features are the same as elsewhere (p. 435). Ankylosis is common. Sometimes the acetabulum becomes very deep and its inner wall bulges into the pelvis (protrusio-acetabuli). Osteoarthritic changes are frequently superimposed when some movement remains after the rheumatoid process has subsided. Local treatment follows the same lines as for osteoarthritis of the hip, but it is exceptionally difficult because the condition is usually bilateral, movement is often greatly restricted and the muscles are atrophic.

OSTEOARTHRITIS

Ætiology

Osteoarthritis is the predominant hip disease of adult life although every sort of bone and joint disease does involve the hip from time to time. The high incidence of osteoarthritis is explained by the hemispherical shape of the joint; lack of congruity of the joint surfaces, from whatever cause, interferes with smooth movement of the joint which then wears out rapidly. Most if not all the conditions listed below cause osteoarthritis for this reason.

1. *Trauma.*
2. *Pre-existing disease.*
   - congenital dislocation.
   - Perthes disease.
   - adolescent coxa vara.
   - rheumatoid arthritis.
   - suppurative arthritis.
   - gonococcal arthritis.
3. *Congenital subluxation and shallow acetabulum.*
4. *Degenerative vascular changes.*
5. *Local disease.*
   - cysts and tumours of bone.
   - synovial osteochondromatosis.
6. *Local manifestations of general disease.*
   - Paget's disease.
   - osteitis fibrosa.
7. *Diseases of the central nervous system.*

Congenital subluxation is insufficiently appreciated as a cause of osteoarthritis of the hip although it is responsible for many of the bilateral cases. Neither the acetabulum nor the head of femur are of normal shape and the acetabulum may be so shallow as to accommodate little more than half the head. Wiberg found X-rays of forty-four such patients in the archives of Stockholm hospitals; he was able to trace eighteen of

them many years later and by that time all had developed gross osteoarthritis. Shallow acetabulum of lesser degree may also be the precursor of osteoarthritis even though comparatively little of the head of the femur, which is often more globular than usual, is outside the acetabulum (Fig. 133).



FIG 133 Osteoarthritis The acetabula are rather shallow and the femoral heads globular in shape.

Pathology

The process begins, as a rule, in the articular cartilage covering the non-pressure areas of the head of the femur, that is opposite the fovea capitis and around the periphery, and later it involves the pressure area at t[illegible] surface, and then [illegible] re been shown by [illegible] pressure and non-pressure areas.*

At the pressure areas, erosion of the articular cartilage continues until it has almost disappeared, and at the same time a thin layer of new bone of sclerotic type is laid down in the basal layers of the cartilage (eburnation). The vascularity of the underlying bone increases altering the bony architecture and reducing its strength until the trabeculæ give way and the top of the head is flattened. Cysts containing a myxoid fibrous tissue, and having an orifice communicating with the joint, also form in the area immediately beneath the layer of sclerotic bone.

At the non-pressure areas, the deep surface of the degenerating articular cartilage is invaded by blood vessels and new bone of a highly vascular type is laid down. The vessels continue to proliferate and the new bone, still covered with a layer of fibrocartilage, gradually extends beyond the original limits of the head to form osteophytes.

Comparable changes take place in the acetabulum. New bone is formed at the non-pressure areas, whilst at the pressure areas, the articular cartilage is eroded and the underlying bone collapses thus permitting the head of the femur to "wander" upwards.

The synovial membrane sometimes, but not always, becomes greatly thickened and convoluted, possibly as the result of an attempt to remove

*M. H. M. Harrison, F. Sckajowicz and J. Trueta Journal of Bone and Joint Surgery 1953 35B 598

the remnants of articular cartilage that have flaked off. The joint capsule may also be greatly thickened, particularly at its upper and anterior portions. It is then little more than a mass of scar tissue which, by its contraction, materially assists in the production of deformity. The soft tissue changes are important factors in the causation of pain which is more closely related to them than to the bony changes.

Summary. There is erosion of the articular cartilage, sub-chondral sclerosis, cyst formation and flattening of the femoral head at the pressure areas; osteophytes form at the non-pressure areas on the inner and lower surfaces of the head and around its periphery. The synovial membrane and joint capsule are usually hypertrophied thus restricting movement and causing deformity.

Clinical Features

The symptoms are pain, stiffness and deformity but the order of appearance varies from patient to patient. One may complain of severe pain and yet have nearly normal movements; another has gross deformity with but little pain and complains only of difficulty with some special movement like getting up from a low chair; the next may be worried chiefly because "the leg is getting short."

PAIN. This is nearly always a prominent feature. The amount of pain is not proportionate to the extent of the X-ray changes but depends chiefly on involvement of the periarticular soft tissues. At first there is often no more than aching of the joint after work, and it disappears with a night's rest only to return next evening; it increases slowly in intensity over a period of years. The characteristic pain is worse on movement and after exercise; rest relieves it, but after resting for a time the joint gets stiff and pain is again felt on commencing to move. When the range of movements is small, each movement is made with caution to avoid pain. On examination pain is produced by passive movements forced beyond the easy range, and there is tenderness to pressure over the joint.

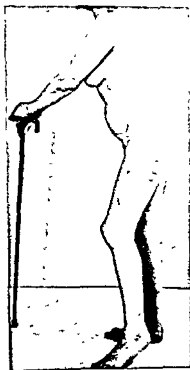


FIG. 134 Osteoarthritis of the left hip

Backache is often severe. It is due partly to the strain on the lumbar spine, itself possibly arthritic and stiff, which has to bend excessively when sitting with a stiff hip, and it is due partly to the lordosis which is necessary to compensate for a fixed flexion deformity of the hip.

Pain in bed at night may be very distressing. When there is fixed deformity it is difficult to find a position that gives support to both back and legs. It is hard to get to sleep because when the muscles relax, the joint moves; and during [illegible] in

movement starts the pain again. The pain is often increased by warmth during the phase when there are active changes in the bone.

STIFFNESS AND DEFORMITY. Movements slowly become more and more restricted; at first a patient may find it difficult to make certain habitual movements such as taking a long step, or sitting astride a horse, but as the disease advances, the typical deformity develops and the hip becomes fixed in flexion, adduction and external rotation (Fig. 134). When standing, flexion is compensated by lordosis, provided the back is not too stiff to adopt this position; adduction causes apparent shortening which may prevent the heel touching the ground unless the other knee is bent. Real shortening may amount to one inch or more.



FIG 135. Severe osteoarthritis of the hips in a woman aged 58 years.

X-rays. The appearance varies somewhat with the etiology because osteoarthritic changes are often superimposed on a pre-existing condition. The cardinal features are:

Narrowing of the joint space which is most marked at the upper, weight-bearing part and is due to erosion of the articular cartilage.

Alteration in the structure of the bone caused by the pathological changes already described. It varies with the extent of the vascular disturbance and may affect the head of the femur, the acetabulum, or both. There may be just a thin band of sclerosis beneath the eroded cartilage (Fig. 133), or there may be extensive formation of cysts with sclerosis between them giving a mottled appearance. The earliest recognisable change is sometimes a small cyst in the upper lip of the acetabulum.

New bone formation occurring at the non-pressure areas. This is sometimes greater at the rim of the acetabulum, as in Fig. 133, and sometimes around the periphery of the head where it joins the neck. There may also be extensive formation of new bone over the inner part of the non-pressure area of the head which is in contact with the acetabulum; this has the effect of forcing the head out of the acetabulum (Fig. 135 *left*).

Treatment

Treatment of the painful hip is one of the most difficult problems confronting the orthopædic surgeon. The disease is not fatal and treatment is directed entirely to the relief of symptoms, principally pain. The pain may become so severe as to make life intolerable and then the patient willingly submits to any procedure that offers relief. Operation is not, however, a panacea and it is of first importance to make certain that the condition after operation is likely to be better than it was before it; the surgeon must therefore have a wide experience of the functional results that may be expected after the different types of operation.

Pain is not caused by erosion of the articular cartilage or deformity of the joint; it is caused by the inflamed and hypertrophied synovial membrane and joint capsule and is associated with movement. It is more troublesome when movements are restricted because the smaller the amount of movement required to cause pain, the more frequently it occurs; the worst pain may be in a joint that has no obvious movement. Treatment may be directed either towards increasing the range of movement sufficiently to enable ordinary movements to be made without pain, or towards abolishing movement entirely. The following methods are available:—

Physiotherapy.
Manipulation.
Walking caliper.
Joint acidification.
Radiotherapy.
Operation — arthrodesis.
arthroplasty.
osteotomy.
denervation.
capsulectomy.

The selection of method depends on the severity of the symptoms, the age, condition and occupation of the patient, and whether one or both hips are involved. There is no half way between palliative, conservative treatment and a major operation. Conservative measures cannot arrest progress although they may give temporary comfort during the earlier stages. Unfortunately every type of operation has some serious disadvantage, and therefore operation should be postponed until the symptoms compel it. Conservative treatment is continued for as long as pain remains tolerable and only then does operation become a reasonable alternative. The indications for operation are discussed below.

Physiotherapy. (p. 452). This is useful early in the disease before there is great restriction of movement, but its effect is not permanent. In advanced disease it may reduce muscle spasm temporarily and provide some hours of comparative ease.

Manipulation. The range of movement m... rove
cases. Manipulation is carried out under genera

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Manipulation. The range of movement may be improved in early cases. Manipulation is carried out [illegible] general an[illegible]ia; considerable

pressure is applied gradually and steadily, but there is danger of fracturing the femur if too great a leverage is used. Weight-traction applied for a week or two before manipulation is valuable.

Caliper. This may give relief if pain is felt chiefly when walking. It is not always well tolerated and should not be pressed on an unwilling patient, or on one who is infirm for other reasons than his hip. The caliper should be weight-relieving, preferably with a moulded-leather "bucket" top, and a knee hinge is fitted for convenience when sitting (Fig. 136).

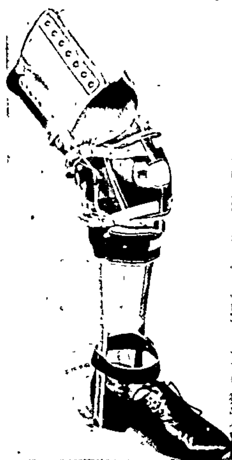


FIG 136 Weight-relieving caliper with "bucket" top and knee hinge and lock

Joint Acidification. See p. 152.

Radiotherapy. Appreciable relief is given to perhaps a quarter of the patients treated in this way. It is, therefore, worth a trial, particularly in elderly people, when the pain is moderately severe but not bad enough for operation.

Arthrodesis. Fixation of the joint by operation eliminates all movement and therefore, all pain at the hip. It is the only certain method of relieving pain and is a most satisfactory procedure, especially in young people, when only one hip is affected. The function with one stiff hip is excellent; there is but a slight limp, nearly every occupation can be followed—one patient of mine returned to work as an able seaman in a sailing vessel—and almost all sports can be enjoyed. A young married woman in her early twenties, who had previously had an arthroplasty, declared about a year after an arthrodesis "now, for the first time, I can lead a normal life like everyone else." The only great disadvantage of arthrodesis is that the loss of movement interferes with sitting, but this is not very serious for a young person. With older people, however, it increases the strain on the lumbar spine and may cause severe pain in the back, particularly when there is already some spinal arthritis.

Arthrodesis is the operation of choice in young people, certainly up to thirty years of age, usually to forty and often until fifty, because it permits almost normal activity and because, unlike arthroplasty, it lasts indefinitely. It is also a good operation in older people, who have already lost all motion at the hip without the back becoming painful. It is contra-indicated when there is a stiff and painful spine, in older patients who have retained a good range of flexion at the hip, and usually when both hips are affected.

Several methods of arthrodesis are available and there are few patients

whose physical condition will not permit one of them when performed in modern conditions with all the aids to surgery that are now available.

1. Simple Excision. The articular cartilage is removed from the head of the femur and acetabulum. After operation fixation in a plaster spica which includes both legs is necessary for four to six months, and even then fusion is uncertain.

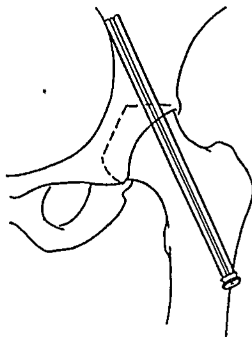


Fig 137 Arthrodesis of hip excision of joint and fixation by tri-fin nail

2. Excision plus Internal Fixation. Removal of the articular cartilage is combined with internal fixation with a long tri-fin nail (Fig. 137). Post-operative fixation in plaster is necessary for about four months or the pin may become loose and fusion is delayed or prevented.

3. Sliding Graft (Fig. 138). The author's operation makes use of a long tri-fin nail to give temporary fixation and a cancellous graft for rapid, permanent fusion. It is both simple and quick to carry out, and is suitable for elderly as well as young people. Moreover, in his experience, it has always been followed by bony union.

The hip is first positioned correctly, that is in neutral rotation and abduction, and 20° to 30° of flexion according to age; the position can be checked radiologically if desired. The anterior and upper surfaces of the joint are exposed by the Smith-Petersen approach and then a tri-fin nail 6 or 6½ inches long is introduced through a separate incision. The tip of the nail should lie in cortical bone close to sacroiliac joint. The cortical bone is removed from the upper surface of the neck of the femur; a graft 3 inches by 1¼ inches is cut from the curved outer table of the ilium immediately above the acetabulum and moved downwards to overlap the neck; it is fastened in position with two screws. Slots are cut in adjacent portions of the acetabulum and the head of the femur in two or three places and packed with cancellous bone. An above-[illegible] e plaster spi[illegible] [illegible]plied to

prevent flexion of the femur around the nail. The patient can sit in a chair after a few days and walk after two weeks; the plaster is removed a month later.

The operation is specially suitable for elderly patients because it greatly reduces the period of post-operative recumbency, and because there is little operative shock since it is unnecessary to dislocate the head of the femur. If the hip is already stiff, it may be desirable to accept the existing

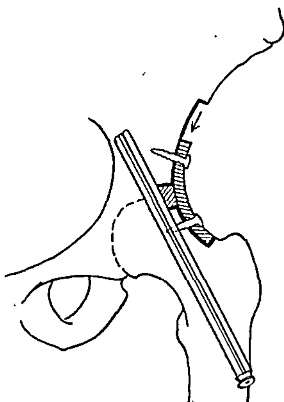


FIG 138 Arthrodesis of hip the author's operation using a tri-fin nail

deformity; the nail is introduced first with X-ray control and then the hip is exposed and the grafts are quickly cut and fixed. The whole operation, provided the application of the plaster spica is left for a day or two, should not take more than half an hour.

4. INTERNAL FIXATION ONLY. An attempt to fix the hip by means of a long tri-fin nail without exposing the joint was popular at one time but it is mentioned only to be condemned. The nail soon becomes loose and the pain, often worse than before, returns quickly.

Arthroplasty. It is natural that patients should be anxious to have a movable hip but, as yet, no operation has been invented that is both reliable and enduring. Modern methods of arthroplasty date from the pioneer work of Smith-Petersen who, just before the war, introduced the vitallium cup. Some years after the war, J. and R. Judet described a replacement arthroplasty in which a prosthesis made of acrylic resin was substituted for the head of the femur. Since then literally scores of different types of prosthesis of every size, shape and material have been manufactured. Unfortunately, plastic prostheses have not stood the test of time;

metal appliances have not been in use so long but the present indications are that they will fare little better. It is my opinion that the vitallium cup remains at the present time the best form of arthroplasty for general use.

VITALLIUM CUP (or mould) arthroplasty. A successful operation gives a good range of painless movements and a stable joint, but this is achieved only after months of conscientious work by the patient (Fig. 139). The results are not certain—a few are brilliant, many are fair and some are failures. The average patient loses the greater part of his pain and retains sufficient movement to sit comfortably; he can walk a fair distance, perhaps a mile or two, but usually with the aid of a stick. About eighty per cent of my patients considered the operation to have been worth-while when asked between two and five years after operation; there is, however, no certainty that these results will remain satisfactory for an indefinite time and there may well be a return of pain in a number of years.

I [illegible] people with osteoarthritis of [illegible]. The chief, indeed almost th[illegible]t be performed for the purpose of improving function only, nor whilst the pain remains bearable. Palliative treatment must be continued for as long as possible and arthroplasty delayed until the pain has become intolerable, and then it is fairly certain the patient will be materially improved by operation. Cup arthroplasty is less likely to be successful in rheumatoid arthritis, or when the neck of the femur is varus or short, or in manual labourers and others who value stability more than movement, or in patients who will not co-operate during after-treatment.

The operation makes use of a vitallium cup to "re-bush" the joint. Vitallium is a non-electrolytic metal that remains inert in the body without stimulating fibrous tissue formation as other metals do. The acetabulum and head of femur are trimmed to an appropriate shape and the cup placed between them. The cup is not fixed in any way and movement takes place on both sides of it, i.e. between the head of the femur and the cup, and between the cup and the acetabulum. After-treatment is prolonged and necessitates six weeks in bed whilst active exercises are carried out, and then about three months walking with crutches. Physiotherapy is continued for six to twelve months.

REPLACEMENT arthroplasty involves removing all or part of the head of the femur and replacing it with a prosthesis shaped to resemble the normal appearance of the part removed; osteophytes around the acetabulum are cut away and the acetabulum itself may be reamed out.

The operation was devised by the brothers J. and R. Judet who used a prosthesis of acrylic resin (perspex); it has the shape of a normal femoral head and is attached to the neck of the femur by a stem passing down the middle (Fig. 140A and B.) The operation is simple to perform, and the after-treatment is comparatively short. The early functional results are good but unfortunately this happy state does not last long and only too often the pain returns within a year or two. The deterioration is sometimes caused by wear, fracture or disintegration of the prosthesis, and sometimes





left hip (he has also a stiff right
the range of movements is good
... without the help of his arms

by lack of congruity between the prothesis and the acetabulum which permits granulation tissue to grow into the gap; sometimes the neck of the femur absorbs so that the prosthesis becomes loose. Most surgeons have stopped using prostheses made of perspex.

Many types of metal appliance have been tried. Several of them are attached to the neck of the femur by a tri-fin nail (Fig. 140C) and these often fail for exactly the same reasons as perspex—even a stem made of steel may "fatigue" and fracture. Nevertheless the use of a metal prosthesis may be indicated in people with intolerable pain who have an expectation of life of only a few years, and sometimes in younger people when other methods are contra-indicated. Attempts are still being made to overcome the known difficulties and devise a satisfactory prosthesis.

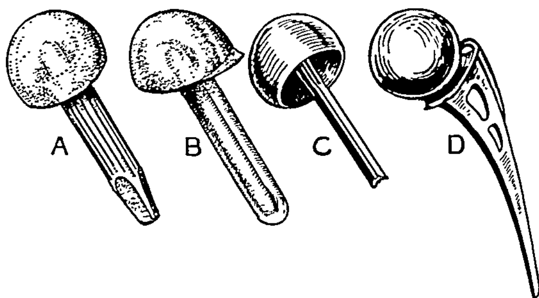


FIG 140 Prostheses for the hip.

A. Old type *Judet* B New type C Fitzgerald *Metal* D. Moore

It is a major problem to know how to treat the many replacement arthroplasties that have failed. The pain and disability are often so severe that something has to be done. It is seldom that enough bone remains to permit a vitallium cup arthroplasty. In the younger age group, an arthrodesis may be feasible. With older people, the best procedure is probably just to excise the head and neck of the femur; this leaves a mobile and relatively painless joint, but it is unstable and therefore walking is restricted. A metal prosthesis with a stem inserted into the medullary cavity of the shaft of the femur is under trial but the long term results are not yet known (Fig. 140D.)

Osteotomy *(McMurray)*. A few surgeons, disappointed with the results of arthroplasty, and encouraged by a survey of the patients treated by the late T. P. McMurray and others of the Liverpool school, are giving this procedure a further trial.

The operation is designed to correct deformity and change the weight-bearing area of the joint. It also reduces the medullary blood-supply of the head and neck of the femur and may therefore restrict new bone formation. There is little operative shock and movement at the hip is retained, but it entails a prolonged period of post-operative fixation that is very trying for older people. The femur is divided obliquely upwards and inwards at such a level that the apex of the distal fragment can be displaced inwards to lie beneath the lower border of the acetabulum (*Fig. 141*). The position may be held by a "blade-plate" which is screwed to the shaft of the femur and has a spike penetrating the neck. A plaster-of-Paris spica is applied and retained until union has occurred, about twelve to sixteen weeks.

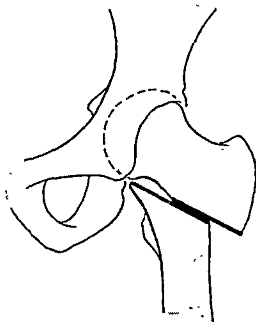


FIG 141 Subtrochanteric osteotomy (*McMurray*)

Denervation. The sensory nerves to the hip are derived from branches of the femoral, obturator and sciatic nerves. Complete interruption of all these sources of supply would clearly rid the patient of his pain. The anatomy is, however, so intricate and so variable that complete denervation is uncertain ; moreover, there is reason to think that a fresh nerve supply will subsequently develop. Good results have been claimed after division of the obturator nerve alone (the intra-pelvic portion is readily accessible, p. 521), but the motor branches are cut at the same time and the improvement may in part be due to relief from adductor spasm. Complete denervation of the hip has not often been attempted, even though it can be managed through two anterior incisions (A. K. Henry).

Capsulectomy. This is really no more than a crude method of denervation because excision of the capsule and synovial membrane, which are the principle sources of pain, must also remove their nerve supply. The operation is followed by a striking reduction in pain, but it is only transient and a new capsule of scar tissue having a new nerve supply is formed quickly.

CONDITIONS AROUND THE HIP

Gluteal Bursitis

There is a large multilocular bursa lying between the gluteus maximus and the great trochanter, and processes often extend between the other gluteal muscles There may also be a separate subcutaneous bursa over the great trochanter. These bursæ occasionally become chronically inflamed, sometimes as the result of repeated occupational trauma as in coal-mining.

Tuberculous Infection. Koch's infection of the gluteal bursa is fairly common. It is not usually associated with other bone and joint tuberculosis, or with active phthisis. The infected bursa forms a tender swelling on the outer side of the hip. There is little disability and the chief complaint is of a constant ache made worse by exercise. Radiographs often show erosion of the outer surface of the great trochanter which has a flattened appearance that is typical of this condition (Fig 142). The erosion

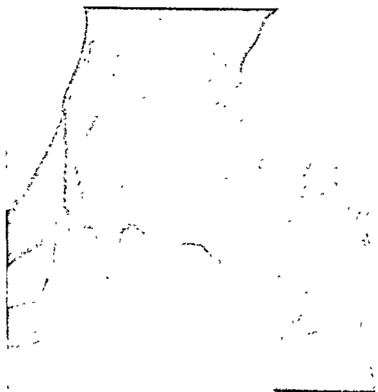


FIG 142 Tuberculous bursitis showing erosion of the great trochanter caused by pressure

is caused at first by intermittent pressure transmitted by the fluid bursa from the contracting gluteus maximus, but later there may be tuberculous involvement of the bone. Sinus formation occurs in neglected cases.

TREATMENT. Complete general investigation is essential. If no other active lesion can be found, the bursa is excised, together with all infected bone, and a full course of chemotherapy given (p. 429). Great care must be taken not to open the hip joint during the operation

Ischial Bursitis

(*Synonym*) Weaver's Bottom

The bursa lying between the gluteus maximus and the ischial tuberosity may, as the colloquial name implies, become chronically inflamed as the result of overuse. If necessary it can be excised, but the operation is not to be lightly undertaken because the ramifications of the bursa are often extensive.

Ilio-Psoas Bursitis

This bursa lies between the tendon of the ilio-psoas, the capsule of the hip and the lesser trochanter. Inflammation is uncommon and diagnosis rather difficult. The patient complains of pain in the groin after exercise; it is caused particularly by movements like crossing the legs when sitting, and sometimes it is very severe. On examination, there is tenderness to deep pressure over the lesser trochanter and in the adductor region, and there is pain on abduction and external rotation of the hip. The bursa occasionally becomes distended to such a size as to cause a swelling in Scarpa's triangle. Symptoms usually disappear with rest aided by short-wave diathermy. Excision involves a deep and difficult dissection in the groin.

Tuberculous infection sometimes takes place by spread from the hip and does not require separate treatment.

Snapping Hip

There is an audible and palpable "snap" on making a particular movement, usually internal rotation of the partly flexed hip. The condition is sometimes bilateral. The snap is caused by a thick band of fascia lying deep to the anterior border of the gluteus maximus slipping across the great trochanter. It does not occur on passive movement when the muscles are relaxed.

The accomplishment is a habit that is regarded by some of its possessors merely as a parlour trick; in others it amounts to a "tic" and becomes a nuisance. It seldom causes pain but, if indulged in frequently, the fascia or an underlying bursa may become inflamed. Treatment is required when the patient is worried by the snap: the band of fascia is divided and sewn back on itself, preferably under local anæsthesia so that the adequacy of the operation can be confirmed before the wound is closed.

Clicking Hip

This is probably a vacuum click similar to that which some people can produce in their knuckles by pulling the fingers. Distraction increases the potential joint space until the suction of the vacuum is great enough to overcome the resistance of the capsule which then clicks back suddenly against the bone. The movement which causes a click at the hip varies with the individual but it is often extension and external rotation. It sometimes occurs in infants, but usually on flexion and adduction.

CHAPTER V

THE KNEE

DISABILITIES of the knee are grouped here under the heading of the most prominent feature regardless of the pathology in the hope that this arrangement will facilitate diagnosis. There is of necessity some overlap: for example, injuries of the internal semilunar cartilage find their place naturally under "trauma" although they are the commonest cause of locking; but there is no difficulty with the diagnosis of a cartilage tear in the presence of locking, only in its absence when it may be hard to distinguish it from other results of trauma.

The following main headings are used :—

Trauma :
- *Lateral strain.*
- *Rotation strain.*
- *Hyperextension strain.*
- *Direct violence.*
- *Chronic knee strain.*
- *Chondromalacia patellæ.*
- *Ruptured muscles.*

Locking.
Chronic pain and swelling.
Swellings around the knee.
Clicking knees.

Examination

The patient is examined lying on a couch in preference to sitting on a chair because muscular relaxation is more readily obtained. The trousers should be taken right off, not just pulled above the knee, so that the condition of the muscles can be seen and felt.

Movements. The range of active movements is noted before examining passive movements; it is important to detect the smallest limitation of movement on one side as compared with the other. When pain is caused the patient should be asked to point out exactly where it is felt.

EXTENSION. Slight limitation is easily overlooked unless special care is taken. The foot is lifted from the couch with one hand and the knee partly flexed with the other; then, whilst the muscles [illegible] relaxed

the knee is allowed to drop straight by its own weight. If there is any limitation of extension, there is not the same "clean" feeling as with a normal knee.

FLEXION. When there is an effusion into the joint, limitation of flexion may be due to the mechanical effect of this.

ROTATION is often overlooked although limitation of rotation with pain referred to the site of injury is common. It is tested by rotating the leg with the knee partly flexed; the normal movement is about ten degrees in each direction.

THE LATERAL LIGAMENTS are examined for laxity by abducting and adducting the extended knee whilst the muscles are relaxed. This is most easily done by holding the leg under one arm when the patient is lying on his back.

CRUCIATE LIGAMENTS. Stability is tested with the knee partly bent; the patient either sits on a chair with the foot resting on the ground, or he lies supine with the knee flexed and the sole of the foot flat on the couch.



FIG 143 Examining for laxity of the cruciate ligaments

The surgeon now sits on the foot to keep it still; the head of the tibia is grasped with both hands and moved backwards and forwards whilst the thumbs exert counter pressure on the condyles of the femur (Fig. 143). Complete muscular relaxation is essential. There is normally an appreciable amount of antero-posterior movement; it is increased in an anterior direction when the anterior cruciate ligament is ruptured, and in a posterior direction when the posterior cruciate is damaged.

Crepitus. Palpable crepitus on active movement of the knee is usually a sign of chronic arthritis, although sometimes lesser degrees can be felt when the joint is apparently normal. *Course crepitus*, or grating, is present in osteoarthritis sufficiently advanced for the joint surfaces to be rough.

Fine crepitus usually indicates that the synovial membrane is thick and rough, as in hypertrophic or rheumatoid arthritis.

Crepitus, usually accompanied by pain, is produced by rubbing the patella against the femur when the articular surface of the patella is rough, as in chondromalacia patellæ.

Tenderness. The site of pain and tenderness must be determined with accuracy. It is particularly important to distinguish between tenderness in the line of the joint and at the insertion of the lateral ligaments (Fig. 144). Tenderness must also be sought beneath the patella after displacing it to one side as this is characteristic of chondromalacia.

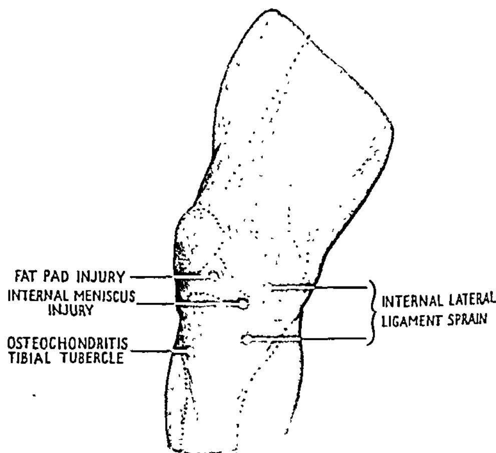


Fig 144 Points of tenderness at the inner side of the knee.

Swelling. This may be due to thickening of the capsule and othe periarticular tissues, or to the presence of synovial fluid or blood within th joint. Capsular thickening can usually be recognised by palpation; joint distended with blood (hæmarthrosis) feels firmer than one distende with synovial fluid.

Effusion. The presence of a small quantity of fluid in the joint ma be detected by compressing the suprapatellar pouch from above down s as to force the fluid into the infrapatellar region where it can be felt o each side of the patellar ligament. If there is enough fluid to lift the patell away from the condyles of the femur, the patella can be back agains them with a palpable tap known as a "patellar tap" ı t

is greatly distended, this is impossible. A patellar tap is therefore present only when there is an effusion of a particular size.

Wasting. The quadriceps muscles waste very quickly when there is any organic disorder of the knee. Wasting is more rapid than might be expected from disuse alone and is probably a reflex phenomenon. It is often most obvious in the vastus internus muscle. Loss of tone can be felt before any wasting is visible and then the muscles, when palpated, have a softer, less resilient feeling than on the normal side.

A difference in the circumference of the two thighs measured at a stated distance above the upper border of the patellae is often used as an indication of wasting. It can, however, be accepted only when there is palpable loss of muscle tone, or the measurement before the injury is known. Allowance has also to be made for the greater development of the leg in a predominantly right-footed person. Mensuration can be used as an indication of progress during treatment.

X-Rays. These are required after all but the most trivial injuries to exclude bony injury, the presence of radio-opaque loose bodies and the rarer diseases.

TRAUMA

Joints depend for their stability primarily on the muscles surrounding them, and secondarily on the ligaments. The muscles absorb the shock of violence tending to distort the joint and strain falls on the ligaments only when the muscles are unable to control the violence, or when they are caught "off their guard." The arrangement of the muscles controlling the knee is such that when the joint is extended, or nearly extended, the leverage is small and their protective power is minimal. In no position have they any considerable control over lateral bending or rotation; for this reason, and because it is so exposed to violence, the knee is particularly liable to injury.

Diagnosis

The knee is a complex structure and therefore is subject to many and various injuries. The signs and symptoms often are not distinctive, yet an accurate diagnosis is important from the point of view of therapy. Many knees have been irreparably damaged as the result of careless diagnosis and incorrect treatment. "Internal derangement of the knee" is a term in common use, but it is not a diagnosis; it is merely a statement that something is wrong inside the joint, and to be satisfied with this is to ask for trouble. The diagnosis is reached by consideration of all the available evidence—history, symptoms, physical signs and X-rays.

The sooner examination is made, the easier it is to make the right diagnosis. The best time is before the victim has got up from the ground after the accident; tenderness can then be localised, the cause of limitation of movement ascertained and unnatural mobility demonstrated before muscle spasm has developed and the knee has swollen. When this

opportunity is not available, as must usually be the case, each day that is allowed to pass without a competent examination makes diagnosis harder. Once the acute signs have subsided, reliance has to be placed very largely on the history, and only too often this is vague. Moreover, unless the more severe injuries, such as rupture of the cruciate ligaments, are treated by early operation, the knee will never become normal.

The first step in diagnosis is to establish the nature and direction of the violence. Precise details of the accident are necessary; it is no use jumping to the conclusion that there is a torn cartilage because the injury occurred at football. The direction of the violence determines the nature of the injury and this plays so important a part in the differential diagnosis of a difficult case that it forms the basis of the following classification under which injuries are discussed.

1. *Lateral strain.*	Lateral ligament injury.
2. *Rotation strain.*	(*a*) Coronary ligament injury.
	(*b*) Semilunar cartilage injury.
3. *Hyperextension strain.*	(*a*) Anterior cruciate ligament injury.
	(*b*) Avulsion of the tibial spine.
4. *Direct violence.*	(*a*) Bruise.
	(*b*) Injury to articular cartilage or bone.
5. *Chronic knee strain.*	
6. *Chondromalacia patellæ.*	
7. *Ruptured muscles.*	

LATERAL STRAIN

Forcible lateral bending results in damage to the lateral ligament on the side opposite to the application of pressure; when the violence is great enough, one or both of the cruciate ligaments may also be injured. The knee is more exposed to abduction than to adduction strains, and therefore the internal lateral ligament is injured more frequently than the external.

Internal Lateral Ligament

The internal lateral ligament is shaped like a broad strap and is attached above to the internal epicondyle of the femur distal to the adductor tubercle, and below to the internal condyle of the tibia (Plate II). It consists of two layers: the superficial layer is a continuation of the deep fascia of the thigh; the deep layer is continuous with the joint capsule and its inner surface is attached to the rim of the internal semilunar cartilage. The ligament is injured by abduction [illegible]ins; it usually

gives way close to the upper or femoral insertion, and less frequently at the lower insertion.

A careful and complete examination must be made immediately after injury, not only because it is easier to make the right diagnosis, but also because it is the only time at which a ruptured ligament can be successfully sutured. If the injured man is put to bed for a few days before diagnosis, the best opportunity may be missed. There should be no hesitation about giving an anaesthetic, if a proper examination is impossible without it.

The extent of damage to the ligament varies from a minor sprain in which only a few fibres are torn, to rupture of the whole ligament, and perhaps also of the anterior cruciate ligament.

Sprain. The internal lateral ligament may be sprained as the result of a blow on the outer side of the knee, specially in football, and also in accidents such as occur in ski-ing when the knee is suddenly and forcibly abducted. On examination shortly after injury there may be some fluid in the joint, the point of maximum tenderness is on the inner side of the knee about one inch above the joint line, there is usually some limitation of extension, and if there is much effusion, of flexion also. Pain is caused by forcing these movements and by abducting the knee. There is no lateral instability unless the ligament is ruptured.

Treatment follows the usual lines of that for a sprain. After a minor injury the knee is strapped at once with elastoplast and normal activities need not be restricted; the strapping should extend from mid-thigh to mid-calf, and it should be applied as soon as possible to limit the size of the effusion. After a more severe injury causing marked pain and swelling, a few days' rest from weight-bearing may be necessary, but it is most important for active use to be resumed as soon as possible. The strapping is, therefore, applied over a layer of lint and removed daily for treatment. This consists at first of massage, faradic stimulation and careful active and passive movements; the range of movements is quickly increased and the muscles are prevented from wasting by graduated exercises. A player with a moderately severe sprain should be able to start training with knee strapped after a week, and return to first-class football after two or three weeks.

Rupture. This may be complete or partial. Both are serious injuries and they are more common than is often supposed. Either may be accompanied by rupture of the anterior cruciate ligament, or occasionally the posterior cruciate, and also a tear of the internal semilunar cartilage (Fig. 145).

Complete rupture of both layers of the ligament is not as a rule difficult to recognise. The patient walks guardedly, if at all, and he complains that the knee gives way inwards. Effusion of blood or fluid into the joint is not great because it escapes through the gap in the ligament into the subcutaneous tissues; there may be visible bruising. The pathognomonic sign is lateral instability with a palpable gap in the ligament when the knee is abducted, but if the pain is severe, it may only be possible to elicit it under an anæsthetic. One of the cruciate ligaments, usually the anterior, is

so often ruptured at the same time that evidence of antero-posterior instability must always be sought.

Partial rupture, which often involves only the deep layer of the ligament, is harder to diagnose. The patient may be walking, although with care, and there is often an effusion into the joint, but there is seldom visible bruising. Some degree of lateral instability is, however, always present but it is less than with a complete rupture, and a gap in the ligament is not necessarily palpable. It is most important to examine for antero-posterior instability.

TREATMENT. *Complete rupture* and partial rupture accompanied by a *ruptured cruciate ligament* should be repaired at operation without delay. Failure to do so may leave an unstable joint with considerable permanent disability. It is even more important to suture a cruciate ligament at once than a lateral ligament, because the cruciate cannot be repaired at a later date and permanent instability is then inevitable.

The internal lateral ligament is exposed by a long vertical incision placed posteriorly and curved forwards towards the crest of the tibia. When the superficial layer of the ligament is intact its fibres should be separated to permit inspection of the deep layer. End to end suture is often possible, but if one end of the ligament is avulsed from its insertion, a suture is passed through a hole drilled in the bone. The internal meniscus, if it has been torn away from the ligament, is removed. The cruciate ligaments must be inspected even when there is no clinical evidence of damage; if necessary, the tear in the lateral ligament is enlarged for this purpose. A rupture in the middle of the ligament can be sutured, but when one or other end is avulsed from its insertion, it is re-attached by a wire passed through the femur (or tibia) to emerge above the condyle (Fig. 151, p. 207). After operation the knee is fixed in a plaster cylinder for a month, but weight-bearing is permitted after two weeks. The joint is then mobilised, but the protection of a back-slab when walking may be necessary for a few weeks longer.

An unstable knee resulting from an untreated tear of the internal lateral ligament can be improved by transposing the tendon of the semitendinosus muscle. The tendon is implanted into bone at the upper and lower insertions of the ligament and the remains of the ligament are wrapped round the tendon and stitched firmly to it.

Partial rupture, provided there is no cruciate ligament injury, may be treated conservatively but the knee must be protected from strain for a considerable time. If there is marked hæmarthrosis, the blood is aspirated and then a pressure bandage is applied to prevent further swelling—a real pressure bandage over a voluminous layer of wool extending the length of the leg. This is kept on for a few days and weight-bearing is avoided. Walking is then permitted with the knee protected by a plaster cylinder extending from above the ankle to the top of the thigh (Fig. 140); the knee should be slightly flexed and a cuff of zinc oxide felt plaster is placed round the ankle to prevent the plaster slipping down. It should be worn for about four weeks and then bivalved to permit daily removal for massage, active exercises, etc.

External Lateral Ligament

The external lateral ligament is a strong cord attached above to the external condyle of the femur just proximal to the groove for the tendon of the popliteus, and below to the head of the fibula. It is in close relation to the tendon of the biceps femoris which divides into two portions to embrace it. The ligament becomes taut on extension of the knee and is relaxed on flexion. The biceps and the ilio-tibial band reinforce it to some extent and protect it from strain.

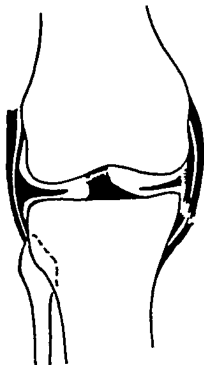


Fig 145 Rupture of one or both layers of the internal lateral ligament is often accompanied by rupture of the anterior cruciate and detachment of the internal meniscus

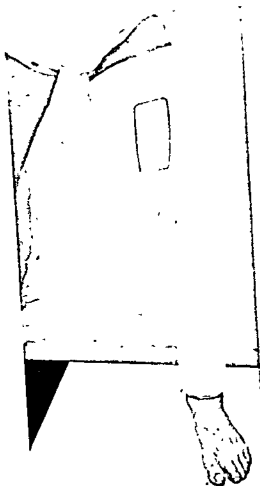


Fig 146 Plaster cylinder.

Injuries of the external lateral ligament are caused by adduction strains and are less common than injuries of the internal ligament. The ligament may be damaged at either point of insertion but the lower is the commoner. Sometimes, instead of the ligament itself being injured, a fragment of the head of the fibula is avulsed. Diagnosis depends on the presence of pain and tenderness at one end of the ligament, and pain on passive adduction. Lateral instability can be demonstrated when there is complete rupture.

Treatment is similar to that for injury of the internal lateral ligament. Complete rupture is not, however, so serious because the ligament is well reinforced by the surrounding structures, and a prolonged period of fixation may therefore be unnecessary. Operative repair, which is but seldom required can be effected by splitting a slice from the biceps tendon and implanting the upper end into the condyle of the femur.

Pelegrini-Steida's Disease

This is a fairly common condition in which a plaque of new bone is formed over the internal condyle of the femur, usually rather high up (Fig. 147). It may occur in association with internal lateral ligament injuries but more frequently it is due to direct violence and it should be suspected with crush injuries which are unduly slow in resolving. The few cases that come to operation suggest that the ossification occurs in an organised haematoma superficial to the internal lateral ligament. Antero-posterior X-rays show a distinct gap between the plaque of bone and the femur.

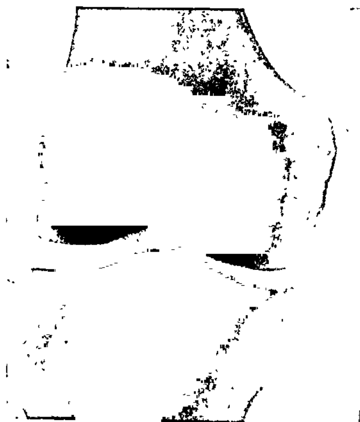


Fig. 147. Pelegrini-Steida's disease.

The condition is frequently mistaken for a sprain of the upper insertion of internal lateral ligament because it follows injury, and because there is pain on the inner side of the knee and limitation of movement. The tenderness, however, is at a higher point than with a sprain, the symptoms are more persistent and the X-ray appearance is characteristic. If detected early when there is but little ossification, progress may be prevented by protecting the knee from movement with a plaster cylinder (Fig. 146). Static quadriceps exercises should be given whilst in plaster but movement is not commenced until the active process of ossification is complete, a matter of some weeks. Operation at an early stage is not successful, but on the rare occasions when symptoms persist after the condition has become stationary, they may be helped by removal of the new bone.

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ROTATION STRAIN

Forcible rotation of the knee may injure one of the semilunar cartilages, or the coronary ligaments which attach them to the head of the tibia. It is seldom that either of these structures is damaged unless there is rotatory movement, but occasionally the coronary ligament is bruised by a direct blow.

The Coronary Ligaments

The coronary ligaments are delicate structures which attach the periphery of the semilunar cartilages to the tuberosities of the tibia. They are only a few millimetres in length, those in association with the internal cartilage being shorter than the external. The internal cartilage has, therefore, a smaller range of movement and the internal coronary ligament is put on the stretch and torn more easily than the external (Plate II).

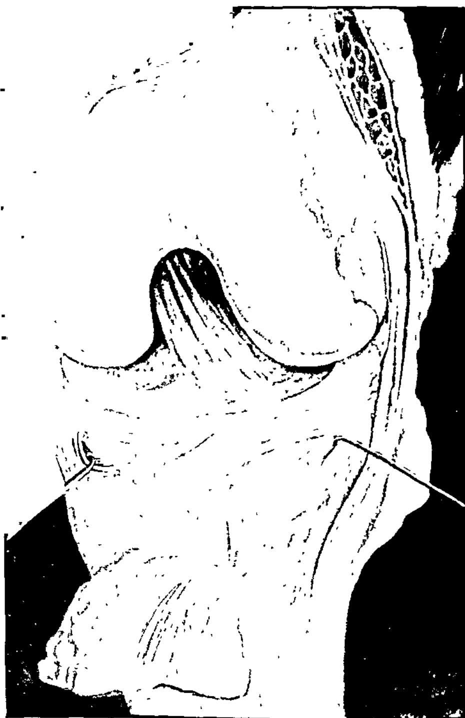
Injury results from the same type of accident as semilunar cartilage injuries, a twist of the flexed knee ; but whereas it is necessary for the leg to be bearing weight for the cartilage to be injured, the coronary ligament can be damaged whether it is weight-bearing or not.

The symptoms are pain and tenderness in the joint line on the inner side of the knee. There is usually an effusion into the joint and extension is slightly limited by muscle spasm. True locking never occurs. There may be difficulty in distinguishing coronary ligament strain from a cartilage injury because the site of maximum tenderness is very similar, and limitation of extension can be mistaken for locking. The differential diagnosis is considered on p. 202.

TREATMENT is as for sprain of the internal lateral ligament but the symptoms are seldom sufficiently severe to require rest in bed. Manipulation during the acute stage is contra-indicated. Most injuries recover in about a fortnight, but some fail to resolve completely and the symptoms become chronic. The patient then complains that the knee is weak and painful and "lets him down" unexpectedly, but there is never true locking or even the sensation of something slipping inside the knee that is so often experienced with a torn cartilage; on examination there is tenderness, limitation of extension and perhaps wasting of the quadriceps. During the chronic stage manipulation under an anæsthetic is of value, the knee being moved through its full range with particular attention to extension and rotation. Manipulation is followed by physiotherapy which must be continued until the wasted muscles are fully restored.

The Internal Semilunar Cartilage

The semilunar cartilages are two fibro-cartilaginous crescents lying between the head of the tibia and the condyles of the femur (Plate II). The internal cartilage is nearly semi-circular ; it is attached by its two horns to the intercondyloid fossæ of the tibia, and at its margin to the capsule of the joint and the deep layer of the internal lateral ligament which is blended with the capsule. The coronary ligament arises from the middle third of



The Right Knee (semi-diagrammatic)

The question of repair of torn semilunar cartilages is of importance. It is sometimes assumed that healing will occur if the fragments are replaced so that they lie alongside one another in the normal position, but there is no evidence that such repair ever does take place, and there is no report of a cartilage being found at operation with a scar that might be due to an old tear. Fibro-cartilage is an avascular tissue and it would be surprising if repair did occur. The nearest approach to repair is when the cartilage is avulsed from its peripheral attachment leaving no cartilaginous rim behind, and then it can re-adhere to the capsule because of the good blood supply of the fibro-fatty tissue joining it to the latter. There is also evidence that after complete removal of a semilunar cartilage a new structure may be formed which resembles a cartilage closely in both shape and consistence. This can only happen if the entire cartilage has been excised without leaving a rim of avascular fibro-cartilage attached to the joint capsule. Walmsley and Bruce have shown it to occur in animals, and it has occasionally been observed in humans. The new "cartilage" is composed of fibrous tissue and can be injured in the same way as a normal cartilage.

History. Primary Injury. The internal cartilage may be torn in any circumstances that fulfil the conditions of rotation of the flexed, weight-bearing knee. This may happen in the most unexpected way, for example, when a woman kneeling in front of the grate as she cleans it turns round to reach for something behind her. Coalminers sustain cartilage injuries more frequently than people in other occupations because they work with flexed knees in a confined space. Many cartilage injuries occur at football, but by no means all football injuries to the knee involve the cartilages. A typical history is that of the player who has his weight on the partly flexed knee preparatory to kicking with the other foot when something causes him to loose his balance; his body swings round but the boot of the standing leg is firmly fixed to the ground and the knee is twisted and injured. Any attempt to move the knee is painful and he finds it impossible to straighten it himself; his friends wrench it straight for him, and although he may be able to finish the game the knee swells a great deal afterwards. By no means all histories are so clear but a similar mechanism can often be elicited by careful cross-examination.

"Locking of the joint" is a common but not invariable feature. The obstruction is caused by the torn portion of the cartilage being nipped between the femur and the tibia during extension. An anterior tear (Fig. 148) may lock the knee so that the last 30° of extension are prevented, but a "bucket-handle" tear tends to limit only the last few degrees; in both cases flexion is free. Locking seldom occurs when the tear is confined to the posterior portion of the cartilage. Unlocking is of even greater diagnostic importance than locking; there can be no doubt that a mechanical block is present when movement is immediately restored by manipulation and the patient feels a click in the joint as the obstruction is removed.

Subsequent Displacements happen very easily once the primary tear has occurred. They are often produced by rotation but no great violence is necessary; sometimes the knee "goes out" for no apparent

the inferior border of the margin of the semilunar cartilage and passe downwards and forwards to be attached to the rim of the tuberosity of th tibia. The synovial membrane blends with the peripheral attachments o the semilunar cartilages but does not cover their weight-bearing surfaces

The function of the semilunar cartilages is apparently concerned wit lubrication of the joint. The lubrication of any bearing requires the for mation of a liquid film between the moving surfaces, and it is most efficien when the surfaces are inclined to each other at a small angle; also, in a bearing like the knee which has a reversible action, provision has to b made to reverse the inclination of the surfaces. The semilunar cartilage are so arranged as to reduce the angle of apposition of the joint surface and provide a reversible action. Removal of a semilunar cartilage reduce the efficiency of lubrication of the knee but not, as far as can be told, t an extent that interferes with function or reduces the life of the joint.

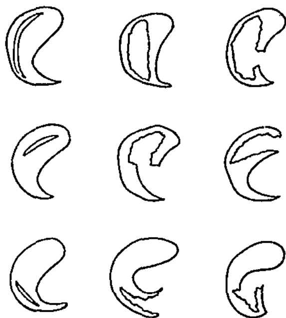


FIG 148 Tears of the internal semilunar cartilage (after Bristow)

Pathology. Accounts of the mechanism of cartilage injuries var considerably but all have one point in common—the injury is caused b rotation of the leg whilst it is partly flexed and bearing weight. A goo description, although a simplified one, is given by Bristow. He say "The primary injury to the cartilage is a longitudinal tear or split in th substance of the cartilage, caused by the direct compression or grindin action of the femur on the tibia, with added trauma caused by a rotatio force, when the weight is borne on the leg with the knee flexed." Bristo considers that the primary injury is a longitudinal tear which may exten along the whole length of the cartilage or else be confined to its anteric or posterior portion. The various secondary displacements that ma occur are shown in Fig. 148. The "bucket handle" type is produced whe there is a complete tear and the central fragment is displaced inwards to li between the condyles of the femur.

X-Rays should always be taken to exclude bony injury or the presence of a loose body in the joint. Air arthrography is sometimes used but the difficulties in interpretation of the films are such that often it is no more reliable than clinical examination; it is of more value to demonstrate cartilaginous, radio-translucent loose bodies.

Diagnosis. *Injuries of the internal cartilage are commoner in* males than females, probably because males are more exposed to trauma. They may occur at any age but they are rare in children and adolescents and the diagnosis should be made only with great caution when the patient is under sixteen years of age.

The history must be taken in detail going back to the primary injury, that is the first occasion on which the knee caused any trouble. It is not enough to be told that the knee was injured some years ago during a game of football; it is necessary to find out exactly what the player was doing, e.g. he was playing on the left wing and about to centre the ball when the right knee gave way under him. *This establishes the fact that* the right knee was exposed to a force tending to rotate the tibia inwards whilst it was flexed and bearing weight, and therefore the internal semilunar cartilage may have been damaged. But if the right knee was hurt whilst he was trying to trap the ball with the right foot, the probability is that a rotation force was applied when the knee was not bearing weight and the cartilage is unlikely to have been injured. The primary injury is usually severe enough to be fixed in the patient's memory although occasionally a torn cartilage is found at operation when no history of injury can be obtained.

Ski-ing injuries to the knee seldom result in damage to the semilunar cartilages although such damage is often wrongly diagnosed. A common type of accident is that of the inexpert runner who crosses his skis and falls backwards and outwards when attempting a downhill Christiania swing; the lower knee may be subjected to abduction, flexion and external rotation violence, or the upper knee to adduction, flexion and internal rotation violence. The knees are relieved of the body weight at the time of greatest strain by the centrifugal force of the body falling outwards and the semilunar cartilages are seldom injured, but one or other of the lateral ligaments or the internal coronary ligament are often sprained. During a Telemark turn the weight is on the leading leg and a cartilage may be torn.

The diagnosis of a torn meniscus in a classical case seen soon after injury is straightforward. There is a typical history, the knee is locked in the flexed position and there is tenderness over the inner side of the joint line; manipulation unlocks the knee and immediately restores full extension. Nor does a typical example of recurrent displacement cause difficulty; there is a history of a primary injury followed by repeated slipping felt at the inner side of the knee, and pain and tenderness over the joint line. Locking occurs in less than half of all cartilage injuries, but when it is present the diagnosis is fairly certain because the presence of other types of loose body which may cause locking is excluded by radiography.

The differential diagnosis when there are chronic symptoms compatible

reason whilst walking on level ground, and sometimes even whilst asleep in bed. The patient frequently is aware of "something moving inside the joint," an observation of diagnostic value.

Physical Signs. PRIMARY INJURY. The most constant finding is tenderness in the joint line (Fig. 144); with anterior horn tears the tenderness is chiefly in front of the internal lateral ligament, and with posterior tears behind the ligament. Fluid accumulates rapidly and distension of the joint may become extreme if the displaced cartilage is left unreduced. There is pain on forcing movement, and usually limitation of movement, the latter being due either to muscle spasm which restricts rotation and therefore prevents full extension, or to locking. Locking can only be diagnosed with certainty after the process of unlocking with immediate return of movement.

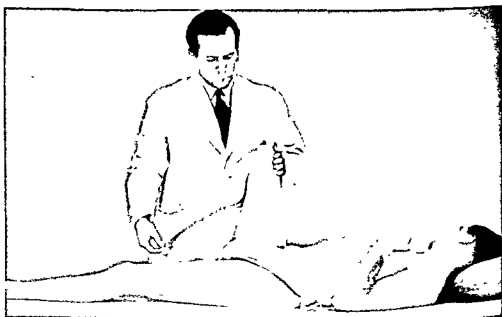


FIG 149 Eliciting McMurray's sign

SUBSEQUENT DISPLACEMENTS. The physical signs are similar, but usually less severe. Precise localization of the point of tenderness assists in distinguishing a cartilage injury from a chronic sprain of the internal lateral ligament. Neither effusion nor limitation of movement are constantly present, but with old-standing injuries there is likely to be some wasting of the quadriceps. Occasionally an anterior tag of torn cartilage can be palpated as a lump which comes and goes in the joint line during movement of the knee. Sometimes there are no physical signs and reliance has to be placed entirely on the history.

McMurray's Sign is present in many patients. It is elicited as follows: with the patient recumbent and the muscles relaxed, the knee is flexed fully and the lower leg externally rotated and abducted (Fig. 149); the knee is then slowly extended whilst maintaining the rotation and abduction. The loose portion of the cartilage may be caught between the femur and the tibia causing a definite click.

around it. This separates the joint surfaces of the femur and tibia and may allow the displaced portion of the cartilage to slip back into place. Another method is to hold the foot with one hand and the knee with the other; the leg is externally rotated, the knee is abducted to open the joint and then, whilst maintaining the abduction and rotation, the leg is straightened with a jerk. Some displacements are reduced by full flexion of the knee.

The question always arises as to whether or no a torn cartilage should be excised at once. The answer depends to some extent on the occupation and mode of life of the patient. If he is a professional footballer, or a coalminer, or follows any occupation that exposes him to rotation strains, he is almost certain to have further trouble; the total period of incapacity will be reduced by operating without waiting for re-displacement and before there is serious muscle wasting. On the other hand less active people may go through life without further trouble and they should be given the opportunity to avoid operation by waiting to see if the displacement recurs.

Subsequent Displacements. The treatment of recurring displacement of a meniscus is, without doubt, by operation. The loose fragment is to all intents and purposes a loose body in the joint, and the inevitable sequel of frequently repeated trauma to the articular cartilage is the development of osteoarthritis. The patient should, therefore, be pressed to have the loose semilunar cartilage removed.

Operation must be carried out in ideal conditions with perfect aseptic technique. It is an operation of choice and as such should only be embarked upon when the right conditions are available; the results of misadventure are too tragic to take any unnecessary risk. The entire cartilage should be excised, not only the detached fragment, and this is usually possible through a single anterior incision. If a narrow strip of the posterior part of the rim cannot be removed in this way, it is better to leave it and see if it causes later symptoms, and this happens in only a small percentage of patients, before making an additional posterior incision. The articular surface of the patella should be examined even when a genuine tear of the semilunar cartilage has been found. Degenerative changes affecting some part of the articular cartilage are quite common and they must be dealt with as described on page 214.

After operation, a pressure bandage is applied and the patient remains in bed for ten days with the dressings undisturbed. During this period flexion is not allowed, but on the second day static contractions of the quadriceps and straight-knee leg raising are commenced. The dressings and stitches are removed on the tenth day, and weight-bearing is permitted. Massage and exercises of increasing strength are given, if possible daily, but the pace must not be forced too rapidly. There may be a small effusion into the joint for a week or two but this absorbs and requires no special treatment. In my experience earlier movement or weight-bearing increases the liability to effusion and retards ultimate recovery. The total time off work varies from two weeks for a clerk, to six or eight weeks for a professional footballer.

with a torn meniscus may be difficult. The most careful surgeon is not right, as shown at subsequent operation, more than seven times out of eight. The two chief difficulties are rotation sprain of the coronary ligament and chondromalacia of the patella.

Sprain of the coronary ligament may closely resemble a meniscus injury. The history is similar in both, and in both there may be tenderness in the joint line, some effusion into the joint and limitation of flexion and extension by muscle spasm. It may be impossible to make a diagnosis immediately, and when there is any doubt the treatment should be as for sprain and the subsequent course observed. If the cartilage is at fault, the knee is likely to return to normal and remain free of signs and symptoms until the next occasion when the torn fragment is displaced. A chronic sprain is liable to exacerbations resembling a recurring cartilage displacement but the knee does not become quite symptom free between attacks. The diagnosis can often be settled by manipulating the knee under an anæsthetic; this usually cures a sprain but it does not prevent the recurrence of cartilage trouble (p. 211).

Chondromalacia of the patella causes chronic symptoms much more often than is generally believed—how often will be appreciated if the articular surface of the patella is examined at every operation. When there are tags of articular cartilage hanging loose from the patella, there is complaint that the knee "catches," that it "lets me down" and even that it "locks." On examination, there are no findings referable to the semilunar cartilage, but there is pain on rubbing the patella against the femur and tenderness beneath its margins (p. 214).

Treatment. Primary Injury. If the knee is locked, it should be freed as soon as possible by manipulation and then strapped with elastoplast. The effusion reaches a maximum in a few hours and it is an advantage if the strapping can be applied before it has developed. The treatment is then as for sprain. Rest from weight-bearing may be necessary for a day or two but active use is resumed as soon as possible; massage, faradism and static contractions to maintain the tone of the quadriceps are started on the first day, and after a few days it should be possible to move the knee through its full range. Treatment is continued until the joint is symptomless and the muscles have returned to normal.

It is important to reduce any displacement of the cartilage as soon as practicable. If it is left unreduced and the patient hobbles about on a bent knee, the synovial membrane is irritated, it becomes thickened and inflamed and recovery is greatly delayed. Reduction may be possible without an anæsthetic, especially if attempted immediately after the injury. The muscles have to be caught "off their guard" and this requires a certain amount of knack. The first attempt is the most likely to succeed because manipulation is painful and the patient becomes wary of subsequent efforts; unless the attempt is made very soon after the injury it saves much pain to give an anæsthetic straight away.

There are several methods of manipulation. A simple one is to place the forearm as a wedge underneath the knee and then flex the knee strongly

coronary ligament do not occur, there are fewer cases of "pseudo-cartilage" injuries that respond to *manipulation*.

Congenital Abnormalities. The semilunar cartilages are developed from a plate of mesodermal tissue lying between the tibia and the femur; this plate divides into two parts and the central zone of each absorbs to form the typically shaped cartilages. Absorption sometimes fails to occur in the *external* cartilage leaving either a complete disc, or an abnormally broad or "discoid" cartilage.

Congenital disc cartilages are not very common, but when present they usually give rise to symptoms sooner or later. Symptoms often begin during childhood or adolescence, usually between six and fourteen years, although the onset may be delayed until adult life when attention is drawn *to the abnormality by an injury*.

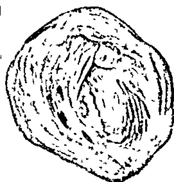


FIG 150 Congenital disc external semilunar cartilage with an oblique split across the centre It was removed from a middle-aged woman who had had no symptoms until she sustained a rotation injury a few months previously

The typical feature is an audible and palpable "thud" or "clunk" during movement. There is seldom any serious disability, but there may be a painful, dragging sensation just before the snap occurs. When the flexed knee is extended, the snap takes place a few degrees before full extension is reached; and when flexing the joint, it occurs a few degrees before full flexion is reached. The snapping may be caused in one or two ways. In one, a ridge develops on the upper surface of the cartilage, and during movement this ridge travels like a wave along the cartilage in front of the advancing femur until, near the extreme of movement, the femur jumps over it; in the other, the whole cartilage is displaced forwards during extension and the femur slips over its posterior border.

Disc and discoid cartilages are apparently more liable to injury than normal external cartilages, and by the same type of accident. The resulting tear may be longitudinal or transverse, or there may be a split which is oblique in the horizontal plane across the central portion of the cartilage. Many disc cartilages are *noiseless and symptomless until after injury* and the abnormal shape is discovered for the first time at operation (Fig. 150).

TREATMENT. In young children the meniscus should be left alone unless it is causing much inconvenience because the symptoms may disappear spontaneously. In adolescents and adults *spontaneous recovery* is less probable; the meniscus is behaving like a loose body in the joint and therefore it should be removed before it damages the articular cartilage.

The External Semilunar Cartilage

Injuries. The external semilunar cartilage is injured less frequently than the internal, the proportion being about one to three, perhaps for the reason that the longer coronary ligament of the external cartilage allows it greater freedom of movement. The external cartilage is not infrequently injured in older children and adolescents, whereas injury of the internal cartilage is uncommon at this age.

The mechanism of external cartilage injuries is similar to that of the internal, that is rotation of the flexed, weight-bearing knee. It may happen that there are acute symptoms closely resembling those with a tear of the internal menicus, except that they are at the outer side of the knee, but more frequently the story is indefinite. The primary injury is less severe. and often there is no history of injury but only a long story of vague trouble. The patient feels the knee to be weak, or has a feeling of insecurity, and he tends to avoid games or occupations that cause rotation strains. He may be aware of something "slipping" on the outer side of the knee; "clicking" on movement is common, but true locking is rare. Pain tends to be rather diffuse, and tenderness may be localized to any point on the outer and posterior aspects of the joint line. McMurray's sign (p. 200), in this case elicited with the knee in internal rotation and adduction, is often positive, but too much importance must not be attached to this because a click can often be obtained at the outer side of a normal knee.

The diagnosis is made largely on the history of "trouble on the outer side of the knee". There are fewer conditions which have to be differentiated than in the case of internal cartilage disorders; external lateral ligament strain is readily distinguished because the points of tenderness are well above or below the joint line, and external coronary ligament st
symptoms v
visible and
Chondromalacia affecting the outer side of the patella may cause similar symptoms, but there is tenderness along the outer border of the patella and beneath it (p. 212).

A characteristic and relatively common lesion of the external meniscus is a tear of its peripheral attachment posterior to the popliteal tendon. There may or may not be a history of an initial rotation strain, but there is complaint of clicking or "catching" during flexion. There is often true locking when the knee is flexed to a right angle or beyond, but unlocking is simple. It may be impossible to see the tear at operation until the anterior part of the cartilage has been detached as far as the popliteus and then the whole structure can be displaced easily into the centre of the joint.

Treatment. The cartilage should be excised. The operation and after-treatment are similar to that for removal of the internal cartilage. Manipulation plays little part in the treatment of external cartilage injuries because of the absence of locking. Moreover, since strains of the

After operation, the knee is fixed in a plaster cylinder for six weeks. Weight-bearing is permitted after a fortnight, and the plaster is bivalved two weeks later to permit mobilization.

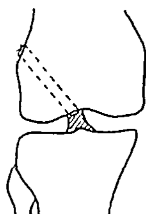


Fig 151 Repair of avulsed anterior cruciate ligament

Conservative treatment is less satisfactory and, if the rupture is complete, it leaves a permanently unstable knee. The leg is fixed in a plaster cast extending from groin to toes for three months in the hope that some fibres have remained intact thus providing a scaffolding along which the ligament can reform.

OLD. In the absence of an intact cruciate ligament, the knee is unstable. The severity of the symptoms varies greatly but the usual complaint is that "the knee lets me down". This may happen only occasionally, or it may be so troublesome that walking on rough ground is difficult and games are impossible. The more severe episodes are followed by pain and an effusion into he joint. The diagnosis depends on the presence of abnormal anteroposterior *mobility which should be sought as part of the routine* examination of every knee.

Many operations have been designed to replace the ligament with ascia, tendon or wire but none is satisfactory enough for routine use. The most helpful measure is to develop the muscles of the thigh to such an extent that they are able to control the joint even in the absence of the ligament.[9] When both cruciates are torn a knee-cage designed to prevent all movement except flexion may be necessary.

Posterior Cruciate Ligament

Rupture of this ligament does not commonly follow hyperextension injuries but it is mentioned here for convenience.

The posterior cruciate ligament is attached below to the posterior intercondyloid fossa of the upper surface of the tibia. It passes upwards, forwards and inwards to its upper insertion into the anterior part of the outer surface of the inner condyle of the femur. The ligament becomes taut on flexion of the knee. It is injured in the more serious type of accident involving dislocation of the knee, particularly posterior dislocation, and the anterior cruciate ligament is often torn at the same time. Just occasionally it is torn by abduction violence after the internal lateral ligament has given way, instead of the more usual anterior cruciate tear.

The symptoms resemble those of rupture of the anterior cruciate ligament, but the increase in antero-posterior mobility is due to the tibia moving backwards on the femur instead of forwards. Treatment follows exactly the same lines and, when possible, the ligament should be repaired at operation within a few days of injury. Untreated injuries are, however, much less troublesome and they do not, as a rule, cause symptoms if the ... iceps are well developed.

HYPEREXTENSION STRAIN

Anterior Cruciate Ligament

A hyperextension strain may injure the anterior cruciate ligament or avulse the anterior tibial spine.

The anterior cruciate ligament is attached below to the upper surface of the tibia just in front of the anterior tibial spine, and it passes upwards, backwards and outwards to the posterior part of the inner surface of the external condyle of the femur (Plate II, p. 197). The ligament becomes taut during extension of the knee and acts as the pivot around which external rotation takes place during the final movement of extension ; together with the posterior capsular ligament it prevents hyperextension.

The ligament may be torn in the middle, or either end may be avulsed from its bony attachment. Sometimes the ligament remains intact and its insertion into the head of the tibia is avulsed together with the surrounding portion of bone which includes the anterior tibial spine. The posterior part of the joint capsule is often damaged at the same time. The cruciate ligament may also be ruptured when the knee is dislocated, and in abduction injuries after the internal lateral ligament has given way.

Sprain. There is a history of a hyperextension injury followed by an effusion into the joint. Full extension is limited by pain which the patient describes as being "inside the joint." There is no antero-posterior instability, but passive antero-posterior movement causes pain. There may be tenderness at the inner side of the knee or behind it due to associated ligamentous strain.

The treatment of a sprain in the acute stage is similar to that of any other sprain. The knee should be strapped to control effusion, and used. Massage and active and passive movements are commenced early, and particular care is taken to restore full extension.

Chronic symptoms occur when the injury fails to resolve completely. The knee feels unstable and hurts with any movement involving full extension. On examination there is no tenderness, but passive extension and antero-posterior movement both cause pain which is felt "inside the joint" and cannot be localized accurately. Treatment is by manipulation under anæsthesia followed by physiotherapy (p. 211).

Rupture. RECENT. Complete or nearly complete rupture of the ligament produces a severe reaction. The knee is distended with blood, there is pain on attempting to extend the joint, and tenderness around it. The pathognomonic sign is abnormal antero-posterior instability (Fig. 143, p. 189). Early diagnosis is so important that if pain is too great to allow this sign to be elicited, an anæsthetic should be given.

Operative repair is not difficult provided it is carried out within a few days of the injury, and it often restores the knee almost to normal. If the ligament is torn in the middle, it is sutured with silk. If one end is avulsed from bone, it is re-attached with a wire loop passed through the holes drilled from the outer side of the condyle of t[illegible] or tibia.

DIRECT VIOLENCE INJURIES

Direct violence such as a kick may injure any underlying structure, i.e. the joint capsule and ligaments, synovial membrane, retro-patellar fat pads, articular cartilage, or bone. The violence may also cause a sprain of the lateral ligament on the side opposite to the blow which gives rise *to symptoms additional to those at the site of the blow.* The semilunar cartilages cannot be torn by direct violence.

SOFT TISSUE injuries due to direct violence are really bruises. The tissues are crushed and there is capillary hæmorrhage into their substance. The symptoms closely resemble those of a sprain—a localized area of tenderness, effusion into the joint and perhaps slight limitation of movement.

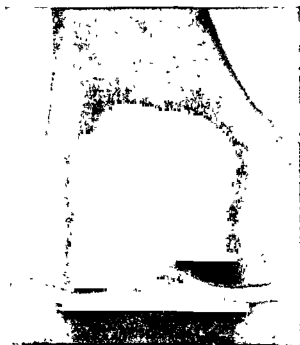


FIG 153 Tripartite patella

THE RETRO-PATELLAR FAT PADS lie in folds of synovial membrane behind and to each side of the patellar ligament. A kick in this region may cause a small hæmorrhage into the fat pads; occasionally a similar lesion results from a rotation strain. The symptoms resemble those of a sprain but the position of tenderness may lead to a mistaken diagnosis of a tear of the anterior horn of the semilunar cartilage. There is a tendency, especially in older patients, for the symptoms to become chronic.

THE ARTICULAR CARTILAGE of the femur is accessible to direct violence when the knee is flexed; it may be bruised or a small fragment may be broken off. The condition is recognized by accurate localization of the point of maximum tenderness which remains constant when the superficial structures are moved. The injury is of some importance because the symptoms are usually very slow to improve, and pain and weakness, which may persist for months, are often uninfluenced by treatment.

Avulsion Fracture of the Anterior Tibial Spine

This occurs as the result of a hyperextension injury instead of rupture of the anterior cruciate ligament. The diagnosis is revealed by the routine radiograph taken in all cases of injury (Fig. 152). The avulsed piece of bone is roughly circular in shape and about an inch in diameter, and it includes part of the articular surfaces of both condyles of the tibia. The anterior horns of both the semilunar cartilages overlap the fragment. The anterior cruciate ligament blends with the anterior horn of the external semilunar cartilage which is therefore lifted up with the fragment. The attachment of the internal semilunar cartilage is not disturbed and the fragment of bone is often displaced above the cartilage; the latter then lies between the fragment and the cavity from which it was torn and interferes with its replacement.



FIG 152 Avulsion of the anterior tibial spine.

Trivial displacement causing no limitation of extension should be treated conservatively. Two or three weeks protection from weight-bearing and active exercises to maintain muscle tone may be all that is necessary.

When there is gross displacement, operation gives the best chance of a good result. The fragment of bone is fastened in position with a peg, and the knee is fixed in plaster in 10° of flexion. Quadriceps contractions are commenced at once and weight-bearing is resumed after ten days; the joint should be protected by a plaster sleeve for six weeks.

Conservative treatment is sometimes attempted even when there is a major displacement. The knee is forced into full extension, and if it so happens that the fragment is not displaced above the internal maniscus, it will be approximated to its bed. Thereafter the knee is fixed in a plaster cylinder in 10° of flexion for about six weeks. At the best, union will occur with some degree of lengthening of the ligament; when the fragment cannot be reduced, the result is indifferent.

PATELLA. A direct blow on the patella may cause an obvious stellate fracture, or sometimes a small crack that is hard to recognise radiologically. Such injuries are accompanied by hæmarthrosis and usually take a very long time to recover. Damage to the articular cartilage is, however, much more common and equally serious because it is one of the causes of chondromalacia, as described on page 212.

Bipartite Patella is found in about 1 per cent of people and can easily be mistaken for a fracture. The appearance is due to a congenital anomaly in which the bones ossify from two or more centres instead of the usual one. There are several variations of which the commonest is for the upper and outer angle of the patella to remain separate from the rest of the bone (Fig. 153). The condition is symptomless and is only discovered during X-ray examination made for some other reason.

Treatment. Direct violence injuries of the soft tissues are treated during the acute stage as a sprain. The knee may be strapped and used normally, or the bruise may be dispersed by massage. Chronic symptoms call for manipulation under an anæsthetic and the joint is moved through its full range, particularly extension and rotation; full movements are afterwards maintained by physiotherapy. Injury to the fat pads is not invariably relieved by manipulation and excision of the affected tissues is very occasionally necessary.

Injury to the articular cartilage should be treated by rest. Hæmarthrosis, if marked, is aspirated and a pressure bandage applied. When the damage is severe, a plaster cylinder may be applied, but it is important to prevent the quadriceps from wasting. At a later stage, short wave diathermy seems to help resolution.

CHRONIC KNEE SPRAIN

Chronic symptoms may be caused by an unresolved sprain of any of the ligaments of the knee, usually the internal lateral ligament, the coronary ligament or the cruciate ligament. The symptoms are due to the formation of a painful scar which restricts the full range of movements (*adhesion formation*). It is not uncommon for the trouble to persist for years either continuously or intermittently, the patient complaining

Wasting and loss of tone of the quadriceps are almost invariably present when there is a chronic lesion of any severity. This is probably a "reflex" phenomenon and is not due in great part to disuse of the limb. The restoration of muscle power is an essential feature of treatment because stability is impaired as long as the muscles remain weak, but it is impossible to develop them fully whilst an organic lesion is present. Since wasting is a secondary and not a primary condition, there is seldom justification for the diagnosis of "quadriceps insufficiency" which is so often made when there is chronic knee trouble. There is no evidence that insufficiency occurs as an isolated entity without another lesion being present.

The first step in diagnosis is to obtain an accurate history going back to the primary injury and by careful cross-examination it is usually possible *to reconstruct the precise details of the accident. This, together with the* clinical findings and a negative radiological examination, is often sufficient evidence on which to base a diagnosis. Chronic sprain of the lateral ligaments can usually be recognized because the areas of tenderness are well away from the joint line, and pain is caused by passive abduction or adduction of the knee. Anterior cruciate ligament sprain is diagnosed when pain is felt "inside the joint" on full extension or on antero-posterior movement, and when there is no tenderness on palpation. With chondromalacia of the patella the history is usually intermittent and there may be pseudo-locking, but there is no restriction of movement; there is, however, pain on rubbing the patella against the femur and tenderness at some point on the border of the patella or beneath it (p. 214).

The chief difficulty in differential diagnosis is to distinguish between certain tears of the internal semilunar cartilage and sprain of the coronary ligament; *in both the history is similar, pain and tenderness are in the* joint line and there may be pain on rotation, flexion and extension. The temptation to attribute all such complaints to "cartilage trouble" must be resisted if only because removal of the cartilage on a mistaken diagnosis retards rather than accelerates recovery.

Manipulation is used as a diagnostic and therapeutic measure. It is likely to relieve a chronic sprain permanently, but a cartilage injury is not improved, except perhaps temporarily. If there is any doubt as to the diagnosis, the knee should be manipulated before deciding on operative measures. Manipulation is performed under general anæsthesia. The joint is moved through its full range, and this includes rotation, abduction and antero-posterior movement. Massage, active and passive movements and graduated exercises are given afterwards, care being taken to retain the full range of movements. The exercises can progress quickly to the heaviest sort and include such activities as bicycling, skipping and weight-lifting. Attention must be paid to the hamstrings as well as to the quadriceps; this can be managed conveniently with a weight and pulley, the muscles being used both as flexors and rotators of the knee. Treatment must be continued until the muscles have regained their full strength; failure of the muscles to recover is an indication that the underlying disorder has not been relieved.

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CHONDROMALACIA PATELLÆ

It has long been known to pathologists and operating surgeons that degenerative changes occur in the articular cartilage of the patella with some frequency but systematic descriptions of the condition did not appear in the literature until after 1930, and even now the significance is not fully understood. Pathological changes of this type are very common and post-mortem examination has shown them to be present in as many as 30 per cent of bodies of eighteen to twenty years of age, the figure rising to over 90 per cent in middle life.

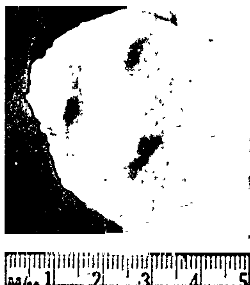


FIG 154 Chondromalacia patellæ Photograph of a patella removed from a young woman who was complaining of chronic pain and swelling of the knee.

Chrondromalacia is a degenerative process even though it begins at so young an age. The causative factor may be trauma. Symptoms are often noticed for the first time some months after a blow of sufficient violence to be remembered. On other occasions there are repeated minor traumata such as may be caused, for example, by the powerful extension of the knee that is found necessary by those who compete in walking races, and by ballet dancers.

The first changes are usually in the central or the lower part of the articular cartilage of the patella. The cartilage loses its lustre, œdematous nodules appear on it, and the surface becomes split and raised by fine longitudinal and transverse fissures (Fig 154). Later the cartilage flakes off leaving a deep erosion which often extends to the underlying bone; the detached fragments of cartilage may grow and become ossified forming loose bodies in the joint. There is sometimes reactive proliferation of the cartilage at the margins of the erosion and between the fissures. The bone itself may be involved and areas of rarefaction and condensation appear in the deeper layers (Fig. 155). Corresponding areas of degeneration often occur in the articular cartilage of the opposing surface of the femur.

and then the ordinary changes of osteoarthritis follow. Synovial proliferation begins at a comparatively early stage, perhaps as a reaction to loose fragments of articular cartilage floating in the joint, and eventually it may become one of the chief causes of symptoms.

The full detail of the natural history is not yet known. It seems that sometimes resolution occurs without there being symptoms at any stage, and sometimes there is no trouble until middle age by which time there may be a well-developed patello-femoral osteoarthritis. Not infrequently, however, symptoms appear in young adults and it is becoming apparent



FIG 155 Chondromalacia patallæ Pre-operative X-ray showing small erosions in the lower third of the articular surface

that chondromalacia is the cause of many hitherto unexplained disabilities of the knee. The great importance of chondromalacia as a precursor of osteoarthritis is discussed on p. 231.

Clinical features. The patient, usually a young adult, or in early middle age, complains of pain, and perhaps of swelling or "catching" of the knee. The onset may be spontaneous, or it may be precipitated by a minor injury such as a blow or a twist. At first the symptoms are intermittent and are noticed only after playing games or other exercise when the knee aches, and there may be a small effusion. Later the ache becomes constant and there is real pain on using the knee. Pain is often felt when going down stairs, an action involving particularly the quadriceps. The pain is not well localised and it may seem to be anywhere around the front of the joint. "Catching," sometimes described as "locking," is complained of when there are partially detached flakes of articular cartilage hanging from the back of the patella, but there is no true locking unless a loose body is present. Once the synovial membrane has become inflamed, pain and swell-

ing are more troublesome, and the periodical exacerbations are slower to subside.

The characteristic physical signs are pain on rubbing the patella transversely across the femur, tenderness at some point on the margin of the patella, and tenderness over the articular surface of the patella. The under surface of the patella can be palpated when the bone is displaced to one side. When the knee is extended and the quadriceps are relaxed the patella can be pushed quite a long way to the side allowing the fingers to be pressed beneath it; in patients with a lax capsule, almost the whole of the articular surface can be felt by displacing it first to one side, and then to the other. The diagnosis can be made with confidence when these physical signs are present whether or not some other lesion such as a torn semilunar cartilage is present at the same time.

X-rays at first show a normal joint, but when destruction of the articular cartilage is sufficiently advanced, the underlying bone is affected and small erosions may be seen (Fig. 155). By the time there is detectable narrowing of the joint space, the condition has become one of frank osteoarthritis. Occasionally the contour of the articular cartilage can be demonstrated radiologically but no reliable method of doing this has yet been described.

Treatment. The question of treatment arises whenever the symptoms and signs are sufficiently advanced for a diagnosis to be made. At the very earliest stage whe[illegible]
energetic use, an expect[illegible]
thermy appears to help, [illegible]
for a time unnecessary use of the knee, particularly such things as games involving running, gymnasium, ballet dancing or mountaineering.

More advanced symptoms call for operation; "catching" of the knee on movement, which is often present when there are loose tags of articular cartilage, is a positive indication. The knee is opened by a long, curved, parapatellar incision and the patella everted for inspection. When only a small fraction of the articular surface is found to be involved, say less than a quarter, the affected articular cartilage is pared with a sharp knife until the bone is exposed. Involvement of a larger area, as in Fig. 154, is probably best [illegible]

perfo[illegible]
chon[illegible]
lar cartilage. If the incision is enlarged and the affected area carefully shaved off, the number of occasions when menisectomy fails to relieve all the symptoms will be reduced.

The after-care and post-operative course are similar to that after menisectomy (p. 203). Removal of a small area of articular cartilage does not appear to delay the return of full function for longer than might be expected on account of the larger incision. Removal of a large amount of cartilage may be followed by a small effusion lasting for two or three months.

The early results of removal of part of the articular cartilage are satisfactory, but the long term results are not yet known; nor is it certain that the ultimate development of osteoarthritis is prevented. Excision of the patella usually restores normal function, but there may be some aching and a small effusion after heavy use, and the knee is rather ugly.

OSTEOCHONDRITIS PATELLÆ

This rather uncommon complaint is in no way connected with chondromalacia of the patella although the symptoms may be somewhat similar. It is probably a form of osteochondritis juvenilis (p. 167) and closely resembles osteochondritis of the tubercle of the tibia and apophysitis of the calcaneus. There are two varieties: in the rarer type, the primary



FIG 156 Osteochondritis patellæ

centre of ossification of the patella is involved and the whole bone undergoes the typical changes. The more usual variety, which was described simultaneously by *Sinding-Larsen* and *Johansson*, affects only the lower pole of the patella where there is sometimes a small secondary centre of ossification.

The symptoms are seldom severe. The patient, usually a boy in the early teens, complains of pain and aching in the knee which is worse after use. There may be tenderness over the lower pole of the patella, and sometimes there is a small effusion into the joint. The X-rays show fragmentation of the anterior part of the lower pole (Fig. 156).

The condition has a short course and the symptoms usually disappear without treatment within a few months. It may be desirable to avoid games for a season, but immobilization is seldom necessary.

RUPTURED MUSCLES

The extensor mechanism of the knee may give way, usually as the result of inco-ordinated movement, at any level and almost any age. The common levels are:

Rectus femoris—middle of muscle belly
lower musculo-tendinous junction
Quadriceps—upper border of patella
associated with transverse fracture of patella
Patellar ligament—any part
Tibial tubercle—avulsion

Rectus femoris

Rupture in the middle of the belly of the muscle is common in middle aged and elderly people, usually those who have suffered a general deterioration in physique and gained a lot of weight. The muscle may be difficult to

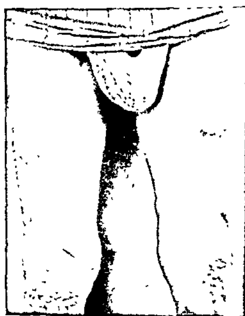


Fig 157 Rupture of rectus femoris at the lower musculo-tendinous junction

suture because it is often fatty and friable; conservative treatment starting with rest and followed by physiotherapy brings about reasonable restoration of function.

The musculo-tendinous junction gives way more often in healthy young adults, for example, when starting to train at the beginning of the season. The muscle belly retracts upwards and when contracted makes a bulge in the middle of the thigh (Fig. 157). The best treatment is by operative repair provided it is carried out without delay and whilst it is still easy to approximate the ends. After operation the patient should be kept at rest in bed for at least three weeks; walking is then permitted with the leg encased in a plaster cylinder which is retained for a further three weeks

The functional results are good although it is unusual for the original power to be restored to the limb.

Quadriceps

The tendon of the quadriceps muscle may be torn at the level of the upper border of the patella, or occasionally a fragment of the bone is avulsed. The injury is essentially the same as a transverse fracture of the patella, and is caused by the same mechanism, that is inco-ordinated muscular contraction.

When the rupture is limited in extent and involves only the central portion of the tendon, *the power of active extension of the knee is very weak, but not completely lost.* An extensive rupture extending into the lateral expansions of the tendon is a more serious injury; active extension of the knee is impossible and a gap is palpable above the patella.

Operative repair is desirable, and when the lateral expansions are involved, almost essential. Conservative treatment is permissible when *the general condition of the patient is unsatisfactory.*

Ligamentum Patellæ

Rupture of the patellar ligament is an unusual injury which occurs (*a*) in middle-aged people taking unaccustomed exercise, and (*b*) as the result of forcible manipulation of a stiff knee under anæsthesia. Diagnosis is simple; *the knee cannot be extended actively, the patella is situated higher* than in the other leg, and a gap is palpable where it should be possible to feel the ligament.

Conservative treatment is unsatisfactory and the defect should be repaired at operation. Within a short time of injury the fragments can readily be approximated and sutured, and an excellent result is obtained. After some time, *however, the gap cannot be closed and end to end suture is* impossible; it is then necessary to bridge the gap with a fascial graft, or to lengthen the quadriceps above the patella, but neither procedure gives as good a result as early operation.

"Pulled Muscles"

This is a common athletic injury usually occurring early in the season when the ground is heavy. It consists in the rupture of a few muscle fibres, usually of the quadriceps fairly high in the thigh, and sometimes of the hamstrings or the calf muscles. It is a minor accident of no serious importance to ordinary people, but it may handicap a first-class man sufficiently to prevent him ever regaining his best form.

The most likely method of restoring perfect function is to insist on immediate active use without a preliminary period of rest. The limb is bound with elastoplast over a wide area; this limits effusion, and also provides resistance against which the contracting muscles can "squash out" the hæmatoma. The ordinary training programme should not be interrupted but competitive sport must be avoided until there is complete recovery otherwise recurrence is almost certain.

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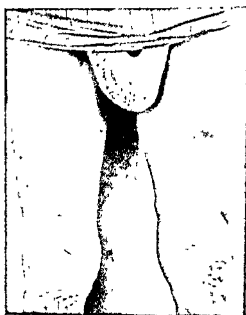


FIG. 157 Rupture of rectus femoris at the lower musculo-tendinous junction

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FIG 158 Sesamoid bone in the gastrocnemius muscle

OSTEOCHONDRITIS DISSECANS

This is a fairly common condition in which an area of articular cartilage together with the underlying cortical layer of bone separates from the articular surface of the joint. It occurs most frequently in the knee and elbow although isolated examples have been described in several other joints. The knee accounts for at least 80 per cent of all cases and the elbow for about 10 per cent. The part of the knee typically affected is the inner condyle of the femur close to the intercondyloid fossa ; less common sites are the articular surface of the patella and the outer condyle of the femur. The condition is sometimes bilateral.

Pathology. No entirely satisfactory explanation of the phenomenon has yet been offered but there are two principal theories :—

(*a*) TRAUMA. Impaction of the patella or the tibial spine against the femur causing a fissure fracture of the affected part of the bone.

(*b*) EMBOLISM. The arteries supplying the juxta-articular region of the bone are functionally end arteries, and if one is obstructed, say by an embolus, the blood supply may be cut off and cause necrosis.

The process commences, usually during adolescence, in the cortical bone immediately underlying the articular cartilage (Fig. 159). A saucer-shaped area of bone is cut off by a thin layer of granulation tissue ; the area is seldom bigger than a halfpenny, but occasionally it is very large

LOCKING OF THE JOINT

"Locking of the joint" is said to be present when movement is restricted by a temporary mechanical obstruction inside the joint. It is usually extension that is affected; there is free painless movement over the greater part of the range, but when the knee is straightened, movement is arrested at a point varying from 10° to 45° short of full extension. "Unlocking" may occur spontaneously, or as the result of manipulation; the patient feels a click as the obstruction is removed and full movement is immediately restored. True locking has to be distinguished from limitation of movement by muscle spasm. The latter occurs when there is a painful condition such as a sprained ligament and full movement is prevented by reflex muscular contraction (*pseudo locking*). True locking should only be diagnosed when there is also unlocking with immediate restoration of movement.

Locking occurs when a loose body or other structure which is free to move inside the joint becomes caught between the condyles of the femur and the tibia. The following classification of the causes of locking applies to all joints, except where structures peculiar to the knee are concerned.

1. *Local Conditions of the Joint.*
   - Torn or displaced semilunar cartilage.
   - Chondromalacia patellæ.
   - Osteochondritis dissecans
   - Osteochondromata, single, multiple or diffuse
   - Fracture of epiphysis with displacement of fragment.
2. *Chronic Arthritis.*
   - Nipped synovial fringe.
   - Detached osteophyte.
3. *Recurrent Dislocation of the Patella.*

The classical loose bodies are those in Group 1 which occur chiefly in adolescents and young adults. A tag of torn semilunar cartilage (Fig. 148) may behave as a loose body, and in fact this is the commonest cause of locking. Locking may occur on any occasion the joint is moved, even during sleep. There is a sudden, very sharp pain of momentary duration which recurs with each attempt at extension until the obstruction is cleared. A synovial effusion usually, but not invariably, follows.

The differential diagnosis causes little practical difficulty. Osteochondritis dissecans, osteochondromata and detached fragments of bone are shown on X-ray examination—the sesamoid bone in the gastrocnemius muscle must not be mistaken for a loose body (Fig. 158). Chronic arthritis occurs chiefly in middle-aged and elderly people and there are other signs of the condition. Recurrent dislocation of the patella, if seen when actually dislocated, is diagnosed at sight by the changed contour of the knee; confusion only arises when the label of torn meniscus has already been attached by some misguided person. Chondromalacia may cause a "catch" on extension, sometimes described as locking, but the history is different and the physical signs are localised to the patella.

may be slightly limited by muscle spasm, and there may be a recurrent effusion. Sometimes there is complaint of "catching" when the knee is straightened. Once the fragment has separated, the symptoms are those of a loose body (p. 218).

Diagnosis is made by the characteristic radiological picture. In the early stage the line of demarcation is clearly shown as a saucer shaped line in one of the typical positions (Fig. 160). After separation of the fragment, the loose body appears free in the joint and there is a corresponding depression in the place from which it has come.

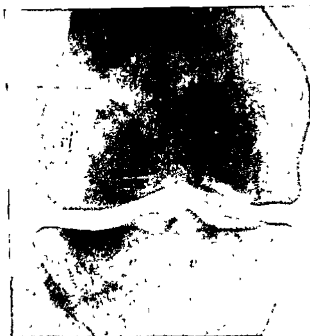


FIG 160 Osteochondritis dissecans

Treatment. A fragment, once separated, should be removed by operation at the earliest convenient moment. Operation is also a good method of treatment before the fragment has separated. The joint is explored and the articular cartilage examined; if the fragment has nearly separated, it should be removed and the edges of the articular cartilage bevelled off. If, however, the articular cartilage appears fairly healthy and there is no actual break of continuity at the circular furrow, the further development of the process can often be prevented. The problem is to re-vascularize the bony portion of the fragment which has been cut off from its normal blood supply at the line of demarcation. This can be effected by drilling several holes through the fragment from the articular surface into the substance of the femur; two or three holes with a 1/32nd inch drill suffice for a fragment of the usual size. The knee is then immobilised for six weeks.

A more conservative attitude may be adopted with young children. A plaster cylinder is applied with the knee flexed sufficiently to prevent pressure on the affected site; weight-bearing is permitted and the cast is worn until the radiological appearance is normal, about six to nine months.

and includes the major portion of one condyle. The articular cartilage at first shows no change, but after a time a circular furrow appears in it, and the furrow gradually deepens until it becomes continuous with the line of granulation tissue in the bone; meanwhile the articular cartilage changes colour until it becomes buff. A fragment consisting of articular cartilage and a thin layer of bone is thus formed; it remains *in situ* attached to the femur only by granulation tissue until it happens to be set free by a minor injury.

Histological examination of the fragment at the stage when there is still continuity of articular cartilage shows fairly normal cartilage adherent

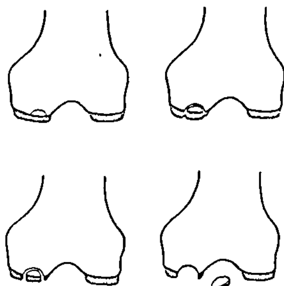


FIG 159 Diagram showing the development of osteochondritis dissecans

to a layer of bone which is in the process of absorption by the invading granulation tissue; degenerative changes in the cartilage commence at a later stage. After the fragment has separated, the granulation tissue on both surfaces of separation is replaced first by fibrous tissue, and finally by fibro-cartilage in which irregular ossification takes place. The loose body, when free in the joint, receives its nutrition from the synovial fluid; it continues to grow, often developing a lamellar structure, and ultimately it may reach a diameter of 2 cms. or more. The affected area of the femur becomes smoothed off and covered with fibro-cartilage, but osteoarthritic changes are common in later life.

Symptoms. The patient is usually in the late 'teens or early twenties, but many cases have been reported in children between twelve and fifteen years of age. Healthy active males are affected more frequently than females. There may be symptoms during the early stages before the fragment has separated, but sometimes they are overlooked and the first intimation of trouble is delayed for years until the loose body has become detached and causes locking.

The early symptoms are weakness of the knee and rather vague pain. There is tenderness on pressure over the middle of the · · · extension

may occur in association with effusion into the joint, especially after an unusual amount of exercise. Locking is a common but not invariable complaint, and sometimes the loose bodies can be palpated. The diagnosis is based on the radiological findings (Fig. 161).

An arthrogram is useful because it shows up unossified cartilaginous bodies of which there are often a good number; indeed, it occasionally happens that none is ossified.

Treatment. The loose bodies should be removed and this is a matter of no great difficulty when only a few are present. In diffuse osteochondromatosis it is impossible to be certain that all have been removed; the

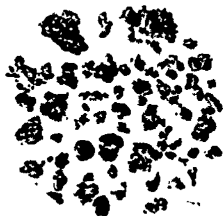


FIG 162 The loose bodies removed from a man with chondromatosis of the hip

osteochondromata are in all stages of development, many being as small as a pin's head, and even prolonged irrigation of the joint does not guarantee a complete clearance. Recurrence is very common, and although a synovectomy may be performed, fresh chondromata continue to develop for a time. It does seem, however, that the condition is self-limiting and the formation of new chondromata eventually ceases. Arthrodesis may be necessary as a last resort after two or three arthrotomies have been followed by recurrence.

RECURRENT DISLOCATION OF THE PATELLA

Non-traumatic habitual dislocation of the patella occurs in young adults, usually females, and often bilaterally. The dislocation is almost always outwards, the patella slipping over the outer condyle of the femur during flexion of the knee. It happens "spontaneously" whilst running or walking; the knee suddenly gives way, there is acute pain and active extension of the limb is impossible. Passive extension of the joint causes the patella to slip back into place.

The history of "something slipping in the knee" which makes it lock renders the condition liable to be mistaken for a torn semilunar cartilage. The knee is usually straightened at once by the patient or his friends and

SYNOVIAL OSTEOCHONDROMATOSIS

This condition, which is characterized by the development of cartilaginous or osteocartilaginous bodies within the joint, may occur in any of the large joints. Those most often affected, in order of frequency, are the knee, elbow, hip, shoulder and ankle. The number of loose bodies may be limited to one or a few, but sometimes as many as two or three hundred have been found in a single joint (Fig. 162). Symmetrical, bilateral affections have been recorded on a few occasions.



FIG 161. X-ray of the knee of a gardener aged 38 from which multiple loose bodies ha already been removed on two occasions

Osteochondromata are usually regarded as benign neoplasm Development begins within the synovial membrane as a small collection cartilaginous cells which grows and often ossifies. As it gets larger it pro trudes into the joint becoming pedunculated, and eventually the pedic breaks off to leave a loose body; this continues to grow in size getting nourishment from the synovial fluid. There are two theories as to the causation. Firstly, it is suggested that frequently repeated minor injuri cause prolonged mild irritation of the synovial membrane which respon by hypertrophy. Secondly, it has been suggested (Kleinberg) that, as result of an abnormality in development, there are aberrant mesenchym rests in the synovial membrane, growth of these is stimulated, perhaps trauma, and finally they undergo cartilaginous degeneration.

When only one or two loose bodies are present the initial symptom usually locking, but when there is diffuse osteochondromatosis the ons of symptoms is often gradual. The patient then notices an increasi difficulty in using the joint and the range of movements gradually decrease but it is astonishing how little disability may be present even when the are scores of loose bodies. Pain is not always a prominent feature but

with the bone into which it is inserted, is transposed to the inner side of the head of the tibia. This procedure has been modified by several surgeons, notably by *Hauser* (Fig. 163B), who transplants the whole patellar ligament thus altering the line of the extensor pull.

2. CHECK LIGAMENTS. There are several methods of making these. *Campbell* (Fig. 163C), cuts a strip from the inner side of the capsule, loops it round the quadriceps tendon and stitches it over the inner condyle of the femur. At *Ober's operation* (Fig. 163D), a strip of the ilio-tibial band, the lower end of which remains attached to the outer border of the patella, is passed across the patella beneath the aponeurosis and sutured to the inner side of the head of the tibia.

Many surgeons postpone operation until the dislocation has recurred so often as to become a real nuisance, but the longer the delay, the greater is the risk of chondromalacia. It is better to operate at once in the hope of preventing damage to the articular cartilage.

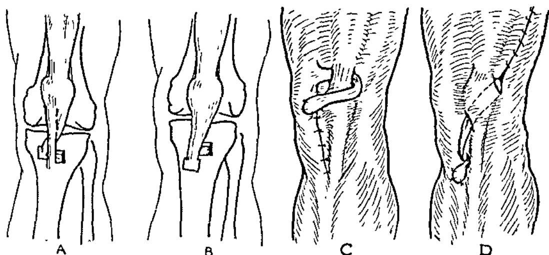


FIG 163 Operations for recurrent dislocation of the patella
A—Goldthwait B—Hauser C—Campbell D—Ober

The choice of operation depends on the careful consideration of the individual patient. A serious degree of knock-knee should first be corrected by osteotomy of the femur; an operation of the Goldthwait type is necessary if the tibial tubercle is abnormally positioned; but when no abnormality of the femur can be demonstrated, as is usual, an operation of either group is likely to be successful provided any abnormal band of fascia that may be present is divided. The author prefers the Hauser operation combined, when the outer part of the joint capsule is very tight, with transposition of a strip of capsule from the inner to the outer side. The joint should be opened in every case to permit examination of the under surface of the patella, and if there are advanced degenerative changes, the patella should be removed. The after-treatment of all these operations involves three to six weeks fixation in plaster-of-Paris followed by physiotherapy; weight-bearing in plaster is usually possible after two weeks.

it may not be seen by a doctor whilst the dislocation is actually presen
Sometimes the patient can give a good description of the knee cap lying o
the outer side of the joint, but often he is only aware of "something goi
out."

On examination, the patella can be made to ride over the out
condyle of the femur by pressing it outwards whilst passively flexing th
knee. This manœuvre is necessary for diagnosis but it must be carried o
carefully or the patella may be dislocated accidentally. It is sometim
possible to dislocate the patella of a "normal" joint in this way. X-ra
do not as a rule show any abnormality, but occasionally it is possible
demonstrate flattening of the outer condyle.

A study by I. Macnab* of the results of treatment has shown th
patello-femoral osteoarthritis is a common sequel. Whereas the resul
when assessed within three years of operation were usually good, all th
patients examined after many years had osteoarthritis causing symptom
and in two of them it was severe enough to require excision of the patell
Routine examination of the patella at the time of operation often sho
degenerative changes in the articular cartilage (chondromalacia), a
clinical evidence may be available before operation if it is sought b
displacing the bone and pressing the fingers beneath it.

Ætiology. The following have been suggested by different autho
as possible causes:—

1. Knock-knee. This deformity alters the line of pull of the extens apparatus and may predispose to recurrent dislocation. Usuall however, there is no knock-knee and it is doubtful if knock-knee alon except an extreme degree, can be held responsible.
2. Failure of development of the outer condyle of the femur which remai abnormally flat.
3. A patella situated abnormally high so that it lacks the support of t outer condyle.
4. Abnormal laxity of the capsule on the inner side of the joint.
5. An abnormal band of fascia leading from the outer border of t patella to the deep surface of the iliotibial band. The iliotibial ba normally moves backwards during flexion and if a band is present, may draw the patella backwards with it.

Treatment. Many operations have been devised depending
different views of the ætiology. All are successful with the majority
patients, but all fail occasionally. Failure may be due to lack of stu
of the factors involved in the particular patient concerned both before a
during operation, and to rigid adherence to one technique in all circu
stances.

The operations in current use can be divided into two groups, b
whichever is favoured, the outer side of the joint capsule should alw
be examined for abnormal bands.

1. TRANSPOSITION OF TIBIAL TUBERCLE. In the original *Goldthwa Operation* (Fig. 163A), the outer half of the patellar ligament, toget

*I. Macnab. Journal of Bone and Joint Surgery 1952, 34A 957

RHEUMATOID ARTHRITIS

The knees are amongst the commoner joints to be affected by this distressing disease, being second in frequency only to the fingers. The diagnosis is simple when the hands are involved, as is usually the case, but it may be difficult on the few occasions when just one knee, or even both knees, are the only joints concerned. Tuberculous disease and a low-grade pyogenic infection can both give rise to a somewhat similar radiological appearance, and in both the sedimentation rate is raised.

An account of the clinical and pathological features of rheumatoid arthritis and an outline of the general treatment are given on page 435. The most important point in the local treatment of the knees, as of other joints, is to prevent the development of flexion contractures during both acute and chronic stages. In the acute stage, the legs should be bandaged with the knees in about 5° of flexion to light plaster-of-Paris, aluminium or polythene splints. The splints are removed daily and the joints moved once through the full painless range; they should be worn at night for as long as the risk of contracture remains.

The disease may subside leaving normal joints, but more often there is some permanent restriction of movement. Fibrous ankylosis is so common that it is most important to ensure that all the joints of the leg and foot are in such a position that, when standing, the centre of gravity is in a stable position, i.e. above the feet. The optimum position for the knees *is between 5° and 10° of flexion.* Two stiff, nearly straight knees are a great disability because of the difficulty in getting up from a chair, but at any rate it is possible to walk after a fashion; with two bent knees, especially if other joints are stiff, walking may be impossible.



Fig 164. Rheumatoid arthritis with fixed flexion deformity. *Note the loss of joint space and the general rarefaction of the* upper few inches of the tibia

Flexion contractures are difficult to correct, but improvement can usually be obtained by continuous traction whilst the leg is suspended in a Thomas's splint with a knee flexion iron attached (Fig. 165). Another method is to use a turnbuckle attached to well-padded plaster cuffs on thigh and leg (Fig. 166). If conservative treatment fails,

CHRONIC PAIN AND SWELLING

Chronic synóvitis is not a diagnosis but a term descriptive of a particular pathological process, i.e. chronic inflammation of the synovial membrane, and this can be caused in several ways. It is an undesirable term because it may give rise to the mistaken impression that a diagnosis has been made, and it really is important to reach an accurate diagnosis before deciding on the line of treatment.

The commoner causes of chronic pain and swelling are:—

Trauma.
- Unresolved sprain.
- Torn meniscus.
- Chondromalacia patellæ.

Loose Bodies.

Chronic Arthritis.
- Rheumatoid arthritis.
- Subacute monarticular arthritis.
- Hypertrophic synovitis.
- Osteoarthritis.

Tuberculosis.

Syphilis.
- Congenital.
- Acquired.

Hæmophilia.

Intermittent Hydrarthrosis.

The differential diagnosis between traumatic and the other causes chronic pain and swelling is seldom difficult: with an unresolved sprain a torn meniscus the symptoms are intermittent, or are subject to freque exacerbation, there is rapid, if temporary, improvement with physi therapy and often permanent relief after manipulation; chondromalac is recognized by the characteristic tenderness around the border a beneath the articular surface of the patella. The presence of a loose body recognized by the characteristic history and the X-ray appearances.

The common causes of chronic pain and swelling during middle age a after are hypertrophic synovitis and osteoarthritis; true rheumato arthritis is less common and it can be recognized because other joints nearly always involved at the same time. Syphilitic arthritis and hæn philia are diseases of children, and tuberculosis is principally a disease childhood although it does occur at all ages. Chronic swelling in you people is occasionally very puzzling and synovial thickening and effusi may persist for months or years defying every attempt at diagnosis. there is reason even to suspect tuberculosis, active treatment must withheld until the matter is settled one way or the other—a tubercule joint treated with short-wave diathermy flares up in a s   cking way!

the characteristic feature is a patchy rarefaction of the femur which gives the X-rays a mottled appearance (Fig. 167). The rarefaction often starts in one condyle of the femur and spreads slowly across the bone; the patella is usually involved.



FIG 167 Subacute monarticular arthritis

Clinically there is gradual development of pain, swelling and limitation of movement. Pain is pronounced and is made worse by exercise; swelling is due mainly to effusion but there may be some periarticular thickening.

Active treatment during the earlier stages increases the pain, and the joint should be placed at rest preferably in a weight-relieving caliper. At a later stage physiotherapy, and sometimes manipulation under anæsthesia, are of benefit. The disease appears to run a course lasting between one and two years, and although it subsides, there is often some permanent disability.

HYPERTROPHIC SYNOVITIS

It is convenient to distinguish this from the other forms of chronic arthritis, although it may not be a separate clinical entity, because the prognosis is different. It is one of the commonest findings at the knee during middle age, and since it affects principally *women in the late forties or fifties*, it is often known as menopausal arthritis. The name is, however, misleading because the disorder is also seen in men, and in both older and younger women; moreover, no direct connection with an endocrine disturbance has been established. It is very often associated

posterior capsulectomy may be necessary. This operation consists in excising the whole of the posterior part of the joint capsule, detaching both heads of origin of the gastrocnemius from the femur and, if necessary, lengthening the *hamstrings* by *oblique tenotomy*; the knee should then be straightened slowly over a period of days to prevent damage to the main vessels and nerves. The operation often gives a satisfactory result with a stable knee and a useful range of movement. Arthrodesis may sometimes be desirable (p. 233).

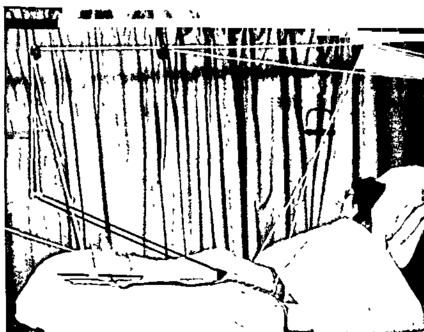


FIG 165 Flexion deformity of knee Correction by continuous traction



FIG 166 Flexion deformity of knee Traction is applied to stretch the joint capsule and a turn buckle to straighten the knee

Subacute Monarticular Arthritis. An affection involving one knee joint *only occurs from time to time.* The ætiology is *still* uncertain and there are not necessarily any manifestations of generalized rheumatoid arthritis. The condition resembles Sudek's post-traumatic atrophy and is probably hyperæmic in origin. The articular cartilage is not affected and

OSTEOARTHRITIS

Osteoarthritis of the knee is common because it is a weight-bearing joint and because it is so exposed to trauma of all sorts. The whole joint is not always affected to the same extent but sometimes the tibio-femoral, and sometimes the patello-femoral sections are primarily implicated. The *tibio-femoral section may be involved because of a major injury such as a* fracture of the tibial plateau; or a loose body composed either of bone or of fibrous tissue, for example a torn meniscus, may damage the articular cartilage each time it is caught between the opposing surfaces; and sometimes it is affected secondarily to the patello-femoral portion of the joint.





FIG 169 Osteoarthritis of the patello-femoral portion of the knee the result of chondromalacia, showing corresponding ridges on both bones

Chondromalacia, which is much more common than is generally appreciated, is the usual cause of patello-femoral osteoarthritis (page 212). The process starts in the articular cartilage of the patella, but the opposing surface of the femur is soon involved (Fig. 168). Osteophytes form at the margins of the patella and these make grooves in the femur which in turn damage the tibia (Fig. 169, and plate VI, p. 447).

Signs and Symptoms. There is gradual and increasing pain and limitation of movement. The pain is often worse on first straightening the knee after sitting, but it wears off with exercise; if the synovial membrane is inflamed, however, pain may be increased by exercise. Locking is not very common but it does occur as the result of nipping of an hypertrophied synovial fringe; unlocking may take place spontaneously but it is often necessary to free the joint by manipulation. Locking may

with osteoarthritis, either as cause or effect, and then it may be responsible for many of the symptoms.

The pathological feature is hypertrophy of the synovial membrane which becomes inflamed, thickened and convoluted. There is some resemblance to the villous proliferation occurring in rheumatoid arthritis, but other joints are seldom affected and there is no general illness. It is not usual for the entire joint to be involved, but only a limited area, often near the attachment of the synovial membrane to bone. Either one or both knees may be affected.

The onset of symptoms is usually gradual, but sometimes abrupt. The knees are painful on movement, specially just after resting, and after bearing weight for some time they may be a little swollen. There is tenderness in the joint line, usually at the inner side, and there may be limitation of flexion and extension. Crepitus or grating on movement is present only when there is associated osteoarthritis.





Fig 168 Chrondromalacia of the patella showing the erosion of the opposing surface of the femur as exposed at operation The patella is reproduced to a rather larger scale

Acute exacerbations coming on abruptly are common and it seems that they are caused by hypertrophied synovial villi becoming caught between the opposing surfaces of the joint. There is a sudden severe pain; the knee is fixed in a position of partial flexion and attempts to straighten it are painful. An effusion of moderate size develops quickly. The worst of the pain subsides gradually during the next week or two but, in the absence of treatment, it may take a long time before full movement returns and the knee is anything like normal.

X-rays may be normal but often there are early, and occasionally advanced, osteoarthritic changes.

The response to physical treatment is good. Short wave diathermy has a most beneficial effect; massage also seems to help, and quadriceps exercises prevent excessive wasting of the muscles. When there is more than a trivial amount of restriction of movement, the knee should first be manipulated under an anæsthetic. Treatment has often to be continued for some months and as a rule the symptoms go entirely within a year or two.

(c) *Arthrodesis* is indicated chiefly in unilateral disease when there is severe pain. One stiff knee gives surprisingly little disability and is a small price to pay for a painless leg (unless it happens that flexion of both knees is essential for some particular occupation). There is only a slight limp when walking, and the chief disadvantage is the way the leg sticks out when sitting. Two stiff knees are most inconvenient because of the difficulty in getting up from a chair, but an agile person may accept this disability to be rid of the pain.

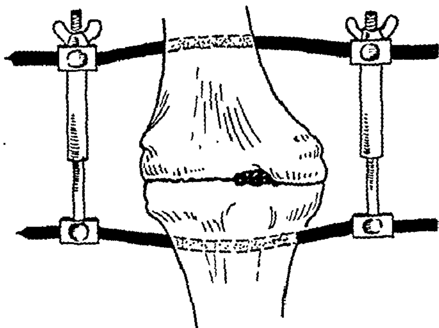


FIG 170 Charnley's compression arthrodesis A *similar* technique can be used with advantage at most joints (*Re-drawn by permission from Compression Arthrodesis* by John Charnley)

Arthrodesis of the knee was formerly rather a lengthy procedure involving many months in a plaster cast before bony union was obtained. This difficulty has now been overcome by the technique of compression arthrodesis which was first described by J. Albert Key and more recently rediscovered and popularised by John Charnley. It is suitable for all patients both young and old and leads to bony fusion in a surprisingly short time. The best position to fix the knee is in about 10° to 15° of flexion because this is less unsightly than a straight knee, and because it gives a mechanical advantage which makes walking easier and less tiring.

After exposing the joint by a large U-shaped incision, the lowest half inch is removed from the condyles of the femur with a tenon saw. When the saw is about half way through, the leg is placed in the desired position relative to the thigh; a second saw is then introduced exactly parallel with the first and the upper surface of the tibia is cut away. Two Steinmann nails are then passed through the bones, the compression clamps are fixed and the wing-nuts tightened until an estimated load of 100 lbs. has been applied (Fig. 170). After operation the patient is kept in bed for a month by which time union has often commenced; walking is then permitted, but the protection of a plaster cylinder is desirable for a further month.

also be due to a detached osteophyte which is lying free in the joint, and then unlocking is usually spontaneous.

On examination there is usually some wasting of the thigh muscles and both flexion and extension may be limited. Effusion and periarticular thickening are not marked unless there is synovial hypertrophy, but considerable effusion may follow a minor strain or nipping of the synovial fringe. There is usually tenderness in the line of the joint, over the retro-patellar fat pads, and over osteophytic outgrowths, specially at the margins of the condyles of the femur and the borders of the patella. Coarse grating is palpable on movement when the articular cartilage is eroded, but finer crepitations are felt at an earlier stage. When the patello-femoral section of the joint is involved, pain is caused by rubbing the patella against the femur, and there is tenderness around and beneath the patella. The X-ray appearances are shown on page 149.

Treatment. PHYSIOTHERAPY. Most patients can be kept tolerably comfortable for a considerable time by physiotherapy. Short-wave diathermy is usually the best method of administering heat; massage assists in reducing periarticular thickening and adds considerably to comfort; exercise is important to keep a good range of movements and prevent the muscles from wasting.

MANIPULATION under an anæsthetic is sometimes necessary to free a nipped tag of hypertrophied synovial membrane. The injured tag is bruised and œdematous and it may adhere to another part of the joint forming an adhesion unless care is taken to maintain movements after manipulation. Manipulation is also of value in increasing the range of movements when it is restricted by contraction of periarticular tissues.

A WEIGHT-RELIEVING CALIPER usually gives considerable relief from pain but it is only occasionally tolerated by the patient. It should be fitted with a knee hinge that can be locked at 180° for walking and released for sitting.

JOINT ACIDIFICATION. See p. 152.

OPERATION is of value in certain patients and the following are the indications :—

(*a*) *A Loose Body* or torn semilunar cartilage should be removed during the earlier stages in order to reduce the rate of deterioration of the joint and prevent the occurrence of acute symptoms due to locking. It should, however, be explained to the patient that the arthritis is not cured by the operation, and that it may get worse later in life. It is seldom advisable to remove a torn meniscus when there is very advanced arthritis as the operation may aggravate the pain.

(*b*) *The Patella* may be excised when the pathological changes are restricted to the patella and the corresponding part of the articular cartilage on the anterior surface of the femur. An excellent result with a good range of movement and almost normal function may be obtained in properly selected cases, but if there are also symptoms arising from the tibio-femoral articulation, the result will be disappointing.

Signs and Symptoms

PAIN. The onset usually is gradual and pain may not be prominent although it is always present in some degree. It is felt chiefly on moving the joint, or on jarring or twisting it. Occasionally the onset is more rapid and accompanied by severe pain.

LIMP is usually present at an early stage, but not invariably. The limp is due to the knee being held in a partly flexed position and it becomes more marked as the deformity increases.

SWELLING is often the first complaint. The synovial membrane is thickened and the joint cavity and supra-patellar pouch become distended with tuberculous material. The swelling often starts on each side of the patellar ligament and increases gradually until the knee has acquired a characteristic bulbous appearance. On palpation there is a typical "doughy" feeling due to the consistence of the material in the joint; this feature is of importance in distinguishing tuberculous infection from other forms of arthritis. The affected knee usually feels a little warmer than the other, and the superficial veins may be distended but the skin is often white in colour.

WASTING of the muscles, which is rapid and affects both calf and thigh, accentuates the appearance of swelling of the joint.

MUSCLE SPASM causing limitation of movement occurs very early. Both flexion and extension are restricted and the typical contraction of the muscles can be seen on making a sharp movement.

DEFORMITY. The knee is at first held in slight flexion because in this position the ligaments are relaxed and the capacity of the joint is increased. At a later stage flexion is increased by the pull of the hamstrings because when the joint is partly flexed they have a great mechanical advantage over the extensors. In the final stage the tibia is displaced backwards on the femur and also rotated externally because of the greater power of the biceps. Some genu valgum is common. The classical deformity, which develops in the absence of treatment, is flexion to a right angle combined with posterior subluxation and external rotation (Fig. 172).

GROWTH. Enlargement of the epiphyses of the diseased knee as compared with the sound one not infrequently occurs in children. Growth in length may also be accelerated and the affected limb becomes longer than the other. The increase in length affects chiefly the tibia and therefore the head of the fibula appears to be lower than normal. The total lengthening may be as much as an inch during the active stage of the disease but the rate of growth diminishes later and there is not as a rule much permanent increase in length.

Diagnosis

IN YOUNG CHILDREN there is seldom any real difficulty. The knee is swollen, movement is restricted by muscle spasm and there is X-ray evidence of diminished density of the bones forming the joint, destruction of bone and narrowing of the joint space (Fig. 173).

TUBERCULOSIS

Tuberculosis of the knee is essentially a disease of early life. It is not uncommon during the first year, and the incidence rises to a maximum at about the fourth or fifth year and then falls gradually. In adults the knee is affected relatively more frequently than are other joints, and adolescents and young adults provide a fair proportion of cases.

The infection, as in other joints, is always secondary to a tuberculous lesion elsewhere in the body. The initial focus in the knee is usually in the juxta-articular bone of the lower end of the femur or the upper end of the



Fig. 171 Tuberculous disease of the knee The infection started in the metaphysis



Fig. 172. Tuberculous disease of the knee showing the deformity in a patient who had had no treatment (by courtesy of Mr. H. J. Seddon).

tibia, and very occasionally in the patella. Sometimes it is in the metaphysis close to the epiphysial line and then the disease is extra-articular for a time, but unless treatment is begun promptly, it soon spreads to the epiphysis and the joint (Fig. 171).

The infection may remain predominantly synovial throughout the whole course of the disease but it is probable that the articular cartilage and subchondral bone are always involved as well, even if only to a limited extent (Chap. XI). There is some dispute as to whether or no the initial infection in such cases is in bone or synovial membrane, but the problem is chiefly of academic interest.

children, when the infection is mainly synovial, healing often takes place within a few months with a good, and sometimes a full range of movements. Even when the bone is seriously involved, the course is greatly shortened and the prospect of mobility improved; and there is an occasional astonishing result when the knee returns almost to normal (Fig. 174).

Children. Local treatment whether or no the infection is predominantly synovial, consists in immobilization of the joint. The following methods may be used:

THOMAS'S BED KNEE SPLINT with fixed extension is suitable for early disease without very much deformity. Good control is obtained and free inspection of the joint permitted, but with infants the splint is hard to apply and nursing is difficult.



FIG 174 Tuberculous disease of the knee with involvement of bone treated with antibiotics, both structure and function returned almost to normal (By courtesy of Dr F H Stevenson, Royal National Orthopædic Hospital)

THOMAS'S SPLINT WITH WEIGHT EXTENSION and a knee flexion iron may be used to correct gross deformity. The direction of pull should be a few degrees less than the angle of deformity; posterior subluxation is corrected by a band passing behind the head of the tibia to lift it forwards. Weight extension is valuable in overcoming muscle spasm but it should not be continued too long because it does not give good immobilization, and because the joint surfaces should not be held apart indefinitely or healing will be delayed.

PLASTER-OF-PARIS, since it gives fair immobilization and is easy to apply, is the method of choice at many hospitals. The plaster should be bivalved to permit regular inspection of the joint. The foot should always be included in the plaster, and in children the pelvis also.

Recumbent treatment is continued until there are no longer any local

In Older Children and Adolescents there may be considerable difficulty in the differential diagnosis from chronic synovitis due to trauma. Occasionally tuberculous synovitis persists for months, and even years, without radiological evidence of bone involvement, and without the characteristic clinical appearance developing. The symptoms usually subside with rest, but tuberculosis should be suspected, although it may be difficult to prove, if they recur each time free use of the limb is permitted. Examination of fluid removed by aspiration seldom yields a positive result, but biopsy of an inguinal gland is very often helpful; biopsy of the synovial membrane is comparatively safe now that the protection of antibiotics is available, and is becoming the method of choice.



Fig 173 Tuberculous disease of the right knee There is irregularity in outline of the femoral condyles, general rarefaction of bone, and enlargement of the epiphyses of the femur and tibia and of the patella.

In Adults, especially during middle age, the disease is often relatively painless. The synovial membrane is affected principally; swelling and restriction of movement increase gradually and it may be several years before advice is sought. Differential diagnosis from other causes of chronic swelling, such as synovioma, may be impossible without biopsy. When the onset is more rapid, differentiation from subacute monarticular arthritis can be most difficult without a long period of observation.

Treatment

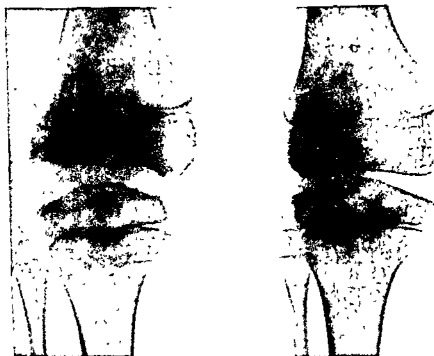
The response to conservative measures is reasonably good but treatment in the appropriate conditions, preferably an open-air hospital, is essential (p. 428).

Chemotherapy has a most encouraging effect on the prognosis. It

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Recumbent treatment is continued until there are no longer any local

or constitutional signs of active disease and the X-rays show tha re-calcification of bone is well advanced. A weight-relieving caliper i then applied and a limited amount of activity permitted.

When the response to treatment has been excellent and it is expecte that a good range of movement will be retained, the caliper is soon dis carded and a normal life cautiously resumed. But when there is conside able destruction of bone, the caliper should be worn day and night until th structure of the bone has returned almost to normal. Weight-bearing i then commenced but, protection from strain should be provided for a lon time by means of a leather corset or similar appliance.

Arthrodesis. The end result whe articular cartilage is fibrous ankylosis. limited amount of movement can be regarded as safe conditions offerin reasonable security from re-activation of the disease, and therefor arthrodesis requires consideration. Some surgeons postpone operation unt about fifteen years of age because of the possible risk of interfering wit growth, but this complication should not occur with a well-planned operatio

The lower femoral epiphysis occasionally becomes distorted by th strain of a stiff knee causing some genu recurvatum, but should th happen it can be corrected by osteotomy.

Adults. The response to conservative treatment is not so good and useful range of movement is seldom obtained. Operative measures ar therefore indicated at a comparatively early stage, but it is important t provide a preliminary period of general treatment in an open-air hospital i order to observe the virulence of the infection and the reaction of th patient. General treatment is also necessary to combat the other foci d disease that necessarily exist; the frequency with which the inguin glands are involved shows that there must be fairly extensive disease of th lymphatic system.

In young adults, when the general condition is satisfactory and it ha been shown radiographically that the local infection has been checked, th joint may be excised and arthrodesed.

Excision and Arthrodesis. The object is to remove all infected ti sues and secure bony union between the femur and the tibia. A wide exposu is necessary and the entire synovial membrane is excised including th supra-patellar pouch and the parts behind the condyles of the femur; th cruciate ligaments and semilunar cartilages are also removed. It is essenti to excise all the synovial membrane or the disease will probably recu The upper end of the tibia and lower end of the femur are divided throug healthy bone and the patella is removed if it is diseased. The ends of th bones are cut at such an angle as to provide between 10° and 15° of flexic at the knee and compression is applied by Charnley's method (p. 233).

Amputation. The response to conservative treatment is less favou able in the elderly and amputation is often the procedure of choice. It ma be indicated occasionally at any age when conservative treatment has bee unsatisfactory, or when there are other major tuberculous lesions and th general condition is poor.

SYPHILIS

Joint lesions may occur in congenital syphilis and during the secondary and tertiary stages of acquired syphilis.

Congenital Syphilis

Infants. Acute symptoms occurring in babies are described with other acute infections on p. 115.

Adolescents. Chronic symptoms are rare but there is a form of chronic arthritis due to gummatous infiltration of the synovial membrane that is very occasionally seen (Clutton's joints). It is characterized by bilateral, fusiform swelling of the knees and very rarely of other large joints. The onset is rapid and the effusion considerable, but the condition is nearly painless. The response to antisyphilitic treatment is good.

Acquired Syphilis

Secondary Stage. There is sometimes an effusion into the larger joints, usually the knees. The distribution is often symmetrical and occasionally several joints are affected. Sometimes it is painful but often there is little if any pain. The size of the effusion may vary considerably during the course of the disease and it can be extreme.

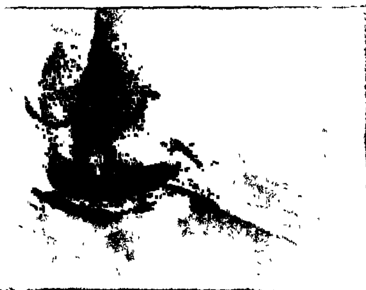


FIG. 175. Charcot's disease of the knee.

Tertiary Stage. The periarticular tissues of the larger joints, usually the knees, may be the site of a gummatous process. Occasionally the articular cartilage and underlying bone are also involved and then there is gross disorganization of the joint.

The commonest manifestation of syphilis in joints occurs in connection with tabes dorsalis (*Charcot's joints*) and is described on p. 154. The knee is affected more frequently than any other joint, usually by the hypertrophic type (Fig. 175). It should be suspected when there is a painless arthritis with gross effusion and rapidly progressive destruction of bone.

or constitutional signs of active disease and the X-rays show that re-calcification of bone is well advanced. A weight-relieving caliper is then applied and a limited amount of activity permitted.

When the response to treatment has been excellent and it is expected that a good range of movement will be retained, the caliper is soon discarded and a normal life cautiously resumed. But when there is considerable destruction of bone, the caliper should be worn day and night until the structure of the bone has returned almost to normal. Weight-bearing is then commenced but, protection from strain should be provided for a long time by means of a leather corset or similar appliance.

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The lower femoral epiphysis occasionally becomes distorted by the strain of a stiff knee causing some genu recurvatum, but should this happen it can be corrected by osteotomy.

Adults. The response to conservative treatment is not so good and a useful range of movement is seldom obtained. Operative measures are therefore indicated at a comparatively early stage, but it is important to provide a preliminary period of general treatment in an open-air hospital in order to observe the virulence of the infection and the reaction of the patient. General treatment is also necessary to combat the other foci of disease that necessarily exist; the frequency with which the inguinal glands are involved shows that there must be fairly extensive disease of the lymphatic system.

In young adults, when the general condition is satisfactory and it has been shown radiographically that the local infection has been checked, the joint may be excised and arthrodesed.

EXCISION AND ARTHRODESIS. The object is to remove all infected tissues and secure bony union between the femur and the tibia. A wide exposure is necessary and the entire synovial membrane is excised including the supra-patellar pouch and the parts behind the condyles of the femur; the cruciate ligaments and semilunar cartilages are also removed. It is essential to excise all the synovial membrane or the disease will probably recur. The upper end of the tibia and lower end of the femur are divided through healthy bone and the patella is removed if it is diseased. The ends of the bones are cut at such an angle as to provide between 10° and 15° of flexion at the knee and compression is applied by Charnley's method (p. 233).

AMPUTATION. The response to conservative treatment is less favourable in the elderly and amputation is often the procedure of choice. It may be indicated occasionally at any age when conservative treatment has been unsatisfactory, or when there are other major tuberculous lesions and the general condition is poor.

INTERMITTENT HYDRARTHROSIS

This uncommon condition, which affects principally women, is haracterized by an effusion into a joint or joints recurring as a rule with egular periodicity. The ætiology is obscure but the disease is commonly ccepted as being similar to angioneurotic œdema.

The onset is usually during adolescence or early adult life, and once stablished it persists for many years. The knees are the commonest oints to be involved although any of the large joints may be affected. It s frequently bilateral but the onset in the second joint may be delayed ntil years after the first, and occasionally four or more joints are involved. The synovial membrane at first is normal but after a time it becomes thickened and inflamed, and eventually a pannus spreads over the articular cartilage. The synovial fluid shows no unusual features by which it can be identified.

Periodicity is a typical feature although occasionally it is absent. The period varies with the individual from four to thirty days, the average being about twelve days and it may take some time to become regular. The maximum swelling is reached in two or three days and then it gradually subsides. During the brief intervals between attacks the joint becomes nearly normal, but with old-standing disease some synovial thickening remains palpable. At first pain is not marked and seems to be due chiefly to mechanical interference by the effusion, but it is more prominent at a late stage when pannus is invading the articular surfaces. Long spontaneous remissions may occur, and there is almost invariably a remission during pregnancy and the early part of lactation.

Treatment. There is no specific treatment. A conservative attitude should be adopted at first and the fullest investigation made. The usual search is made for focal sepsis, the anaphylactic reactions are tested and the patient is immunized against any substances causing a reaction. Psychological examination is important because some early cases are claimed as entirely relieved after psychotherapy.

The majority of patients fail to respond to conservative measures and sooner or later the inconvenience of the recurring disability becomes so great that they demand further interference. Complete excision of the synovial membrane is then indicated. The operation gives a movable joint and on the whole is worth while, but unfortunately the new lining which forms in the joint sometimes produces fluid as rapidly as did its predecessor. In spite of this risk the operation is worth performing—patients so appreciate even a temporary relief from symptoms that they come back and demand that it is repeated.

Arthrodesis is seldom advisable owing to the frequency of bilateral involvement. Even when only one knee is giving serious trouble it is dangerous to stiffen it permanently because the other may later get worse, but just occasionally, when there is gross destruction of the articular cartilage, the pain may be so severe that arthrodesis is the only way to relieve it.

HÆMOPHILIA

Hæmorrhage into a joint is a common manifestation of this distressing disease. The knee is involved most frequently but sometimes the hip, the elbow and occasionally the smaller joints are affected. Bleeding is often started by a minor injury or sprain.

A single hæmorrhage may be absorbed without damaging the joint, but repeated hæmorrhages cause serious disorganization. The joint capsule is stretched and weakened, the synovial membrane hypertrophies and proliferates, and its surface becomes covered with pedunculated, polypoid excrescences. The articular cartilage degenerates and flakes off, and ultimately osteoarthritic changes supervene. The interior of the joint is stained brown.

The diagnosis is obvious except during the first attack. There is a sudden hæmorrhage into the joint, often after a trivial injury that would not be expected to produce such a result. There may be a slight fever, the joint is swollen, tender and feels firmer than with a serous effusion.

The blood gradually absorbs with rest and the symptoms subside. The joint returns almost to normal after the first few attacks, but once deterioration has commenced, each subsequent attack leaves it worse and it becomes permanently painful and swollen, and the muscles waste.

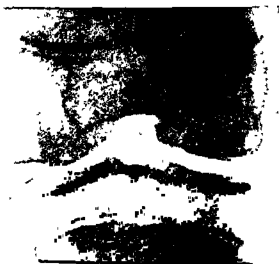


FIG 176 Hæmophilic knee The outline of the femoral condyles is irregular and the epiphyses are enlarged

Treatment. After a fresh hæmorrhage complete rest with the leg bandaged to a plaster back-slab is desirable until the blood has been absorbed. The joint should be aspirated, and if a solution of hyaluronidase is instilled, it is believed to promote dispersal of the blood. If there are frequent attacks, the knee should be protected by a walking caliper.

The administration of gamma globulin will usually arrest persistent hæmorrhage and may even make operation reasonably safe on the few occasions when there is an imperative indication; unfortunately, when continued indefinitely, the effect does not last and the risk of further bleeding is not removed.

teens and the symptoms are pain and swelling. Pain is usually, but not invariably, present and is worse after exercise; there is always swelling and sometimes this is the only symptom. On examination there is tenderness over the tibial tubercle, swelling and frequently some heat; passive movements are painless, but *active extension may cause pain*. The bursa situated deep to the patellar ligament sometimes becomes inflamed and distended, and then pain on active use is more marked.

X-rays (Fig. 178) show irregularity in the ossification of the tibial tubercle. The outline is irregular and there are patchy areas of rarefaction and sclerosis. Because the normal tibial tubercle is subject to considerable variation both in outline and structure, the diagnosis should not be based on the radiological appearances alone but made in conjunction with the clinical findings.

Treatment. The disease runs a course lasting from a few months to two years, and complete anatomical and functional recovery takes place



Fig 178 *Left* Osteochondritis of the tibial tubercle
Right The other knee is normal

in the absence of all treatment. There is no necessity for physiotherapy or for immobilization of the knee, but it is desirable to avoid games and strenuous exercise *as long as pain persists*.

Resolution can be accelerated by increasing the local blood supply of the tubercle by drilling holes through it into the shaft of the tibia. The operation may be justifiable, particularly in older patients, when there is a special need to become fit for games as quickly as possible.

Inflammation and enlargement of the bursa behind the patellar ligament occasionally cause sufficient pain to call for excision. The enlargement may persist for many years, and give rise to symptoms for the first time during adult life. Sometimes trouble is caused by fibrinous bodies developing within the bursa.

SWELLINGS AROUND THE KNEE

The majority of swellings around the knee are caused by enlargement c structures peculiar to the knee, but it must be remembered that othe tumours such a lipomata and fibromata also occur. Many of the swelling are cystic but they are readily seen to be distinct from swelling of the who knee due to effusion into the joint.

The commoner causes of swellings are :—

Anterior.

Osteochondritis of the tibial tubercle.
Prepatellar bursitis.

Posterior.

Popliteal hernia.
Semimembranosus bursitis.
Popliteal aneurism.

External and Internal.

Cysts of the semilunar cartilages.

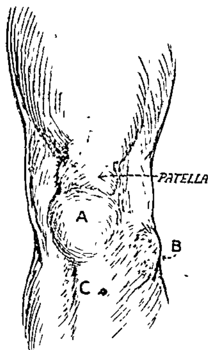


Fig. 177. Swellings around the knee.
A. Prepatellar bursitis.
B Cyst of the external cartilage
C Osteochondritis of tibial tubercle.

OSTEOCHONDRITIS OF THE TIBIAL TUBERCLE

(*Synonym*) Osgood-Schlatter's Disease

An expansion of the upper epiphysis of the tibia extends downwards in front of the shaft to form the tibial tubercle. This tongue of ossifying cartilage is subject to a disorder that is possibly analogous to Perthes disease of the hip and Köhler's disease of the tarsal scaphoid. The pathology is discussed under Perthes disease on p. 167.

Males are affected more frequently than females, perhaps because of the greater liability to trauma. The onset is typically [illegible] the early



Fig 179 Air arthrogram showing posterior herniation of the knee.

True posterior herniation of the synovial membrane of the knee occurs when the capsule has been weakened by infection or by arthritis, and sometimes without demonstrable cause (Fig. 179). The hernial orifice is usually at the weakest part of the posterior capsule which is just below the centre of the oblique ligament. The hernia passes backwards between the two heads of the gastrocnemius to become subcutaneous and then it tends to gravitate down the calf. The visible swelling is level with the popliteal crease or below it. Occasionally there are multiple herniæ.

Posterior herniation is accompanied by more severe symptoms than is a semimembranosus bursa. There is often pain, effusion and muscular wasting; the leg below the knee may swell because of pressure on the popliteal veins. Symptoms in the knee frequently precede the appearance of the hernia.

Treatment. Investigation of the ætiology must always be made to exclude tuberculous infection. When of non-infective origin, the hernia may be excised and the opening through the capsule sutured. This relieves symptoms due to the hernia but not, of course, those due to concomitant arthritis; unless the effusion can be got rid of, there is quite likely to be a recurrence.

PREPATELLAR BURSITIS

Simple enlargement of the prepatellar bursa (*housemaid's knee*) may be caused by repeated minor traumata, or by a single blow, but often it occurs without apparent cause. The large sac forms a prominent swelling over the lower part of the knee which cannot readily be mistaken for anything else (Fig. 177). Sometimes a hæmorrhage into the bursa causes a hard swelling resembling a solid tumour.

Treatment. Aspiration of the fluid is frequently followed by recurrence. Aspiration and injection of a sclerosing fluid may be successful in obliterating the bursa but it sometimes leaves a subcutaneous scar that remains tender for a long time and interferes with kneeling. Excision of the bursa is the best method of treating chronic enlargement; it is carried out through a lateral incision to avoid leaving a cutaneous scar at a place where it is subject to pressure.

Infection of the bursa is common and is accompanied by the usual signs of acute inflammation. The patella and the knee joint, which are separated from the bursa by the thick tendinous expansion of the quadriceps, are seldom infected secondarily, but sometimes there is a sterile effusion into the joint. The infection can often be controlled by penicillin administered either by injection into the bursa or systemically. If an incision is necessary for drainage, it must be placed laterally and never in the mid-line. Recurring infection calls for excision of the bursa.

Prepatellar neuralgia

This is a well-defined condition described by G. C. Gordon* in which a neuralgic pain is felt deep in front of the knee. It follows a blow on the patella of sufficient violence to be remembered and gives rise to persistent pain of neuralgic type which is aggravated by use. It may become troublesome enough to make it difficult to kneel and even to climb stairs.

Examination shows an accurately defined point of tenderness at about the middle of the outer border of the patella. The prepatellar bursa may be inflamed and enlarged. Treatment consists in excising the neuro-vascular bundle supplying the bursa which is to be found in the subcutaneous tissues close to the tender point.

POPLITEAL HERNIA

(*Synonym*) Baker's Cyst

Morrant Baker, in 1897, described a number of cases in which there was a large cyst at the back of the knee communicating with the joint. The underlying pathology was diverse, some of the knees being tuberculous, some osteoarthritic and some neuropathic; the only common feature seems to have been that the knee was distended with fluid. "Baker's cyst is neither a clinical nor a pathological entity and the continued use of the term can only cause confusion.

*Gavin C. Gordon. Journal of Bone and Joint Surgery 1952, 34B.

follow that the cyst is of recent growth because small cysts may remain symptomless for many years. The usual complaint is of pain in the knee made worse by exercise, and the swelling may or may not have been noticed by the patient. There is often a history of trauma which either precedes the onset of symptoms or causes an exacerbation. Examination shows a swelling in the joint line or just below it, usually in front of, but sometimes behind, the external lateral ligament; when small it is detected only on careful palpation and comparison with the other knee. The larger cysts are quite tense and are often mistaken for bony protuberances.



Fig. 180 A large cyst of the external meniscus.

Treatment. It is not necessary to operate on every patient, particularly older people, because often the symptoms are not due entirely to the cyst. In active people, however, a cyst of any considerable size causes sufficient irritation to the surrounding structures to be a constant trouble and operation is desirable. Local removal of the cyst without the semilunar cartilage from which it springs is frequently followed by recurrence. Excision of the cyst and cartilage together may cause unnecessary damage to the external capsule of the joint. It is usually desirable to remove the cartilage separately; the cyst can then be excised through a short vertical incision.

CLICKING KNEES

Audible clicking is sometimes the chief symptom of which a patient complains. It may be accompanied by pain but often there is no other symptom than noise.

"VACUUM CLICK"

This is the commonest type. It may occur in any joint and can be produced by many people at will, e.g. in a metacarpo-phalangeal joint by pulling the finger. A possible explanation is that slight separation of the joint surfaces increases the potential capacity of the joint and creates a vacuum; the capsule which has momentarily been held away from the bone is then sucked in with a snap.

Clicking joints of this type may be of great annoyance; in an extreme example a simple action like walking up stairs is accompanied by a regular fusillade. The clicking may occur during normally executed movements, or it may only happen when a particular twist is given to the joint and some people form the habit of always moving in this peculiar way. Treatment is only possible in the latter, the abnormal movement being analysed and explained to the patient who may then be able to break the habit.

SEMIMEMBRANOSUS BURSA

There are six bursæ situated on the postero-internal aspect of the knee. The principal one, that which usually gives rise to trouble, lie between the inner head of the gastrocnemius and the tendons of the semimembranosus and semitendinosus muscles. It often communicates with neighbouring bursæ and usually also with the knee joint; the opening into the knee lies high up under cover of the inner head of gastrocnemius.

Simple enlargement of the bursa occurs at any age from childhood onward and it is more frequent in males than females. It might be expected that a bursa communicating with the knee would not become distended with fluid unless the joint were distended also. The usual explanation of the phenomenon is that the muscles exert a valve-like action on the communication which prevents the bursa emptying; variation in the size of the bursa is explained by the occasional release of the valve.

The enlarged bursa appears as a swelling on the posterior aspect of the knee medial to the mid-line and either above or level with the popliteal crease. It is more prominent when the knee is extended. On palpation when the muscles are relaxed by flexing the knee, it is felt as a tense, round movable swelling. The bursa cannot be emptied into the joint by pressure even when a communication exists. An effusion into the knee is only occasionally present. Pain may be caused by irritation of the bursa by muscular activity.

Treatment. If symptoms are troublesome, the bursa may be excised. The incision should be transverse because a straight vertical scar behind the flexure is likely to contract. The dissection is carried to the base of the bursa which is always adherent to the gastrocnemius and semimembranosus muscles.

CYSTS OF THE SEMILUNAR CARTILAGES

These are the only important cause of swelling on the outer or inner sides of the knee and they account for almost all swellings except those due to superficial tumours such as lipomata and fibromata. Cysts are more common in connection with the external than the internal cartilage, the relative frequency being about 8 to 1.

The cysts are said to originate in remnants of the undifferentiated mesoderm from which the semilunar cartilages are derived. They are multilocular, lined with endothelium and filled with gelatinous material. They usually develop in the cartilaginous substance of the peripheral convex border of the meniscus, as a rule in the middle third; very rarely they are situated at the anterior or posterior horn close to the insertion in the tibia. They are not connected with the joint capsule which is stretched over them, much thinned and attenuated when the cyst is large. Occasionally the cyst passes between the fibres of the capsule and appears as a sessile or pedunculated subcutaneous swelling.

Patients may present themselves for advice for the first time at a period from adolescence to late middle age. In the lat[illegible] it does [illegible]

CHAPTER VI

THE FOOT AND ANKLE

The feet are the hardest worked and most mis-used parts of the body. They have to carry the whole body weight and withstand the shock of meeting the ground at each step, they are confined in shoes that are often ill-fitting, and they have to walk on surfaces that seem to get harder each decade. It is surprising, not that there is so much foot trouble, but that there is not more.

The foot is an intricately fashioned structure and its careful balance is easily disturbed. Every disorder in function, and every minor deformity or injury that causes pain, produces further disorder in function and yet more pain. It is not always easy to decide the primary cause of trouble because pain may either be felt locally at a deformed bone or joint, or it may be felt chiefly elsewhere, for example under the outer metatarsal heads on which undue weight is being taken to avoid a bunion.

The key to understanding lies in the study of function and of the mechanism by which pain is produced. There is no mystery about the pain and its causes are exactly as elsewhere in the locomotor system. Deep pain is usually due to tension on ligaments or fascia, to pressure on damaged or inflamed joints, or to ischæmia; superficial pain is caused by irritation of the skin. Deformities do not always cause pain; a large-scale study of infantrymen by Buxton showed that men with minor deformities were no more likely to report sick on account of their feet than those with apparently normal feet.

Children seldom suffer from painful feet except from visible causes such as chilblains, warts and corns; deep-seated pain like that due to chronic foot strain or metatarsalgia is uncommon. There are, however, a few conditions causing deep pain in children, for example osteochondritis of the navicular, the calcaneus or the metatarsals; tuberculosis is not common but it may affect any bone or joint in the foot. Most problems in children's feet are concerned with their shape or function, e.g. "flat foot," hallux valgus, clawed toes, etc., and the possible effect of such deformities in later life.

The posture and movements of the feet are described on p. 16.

EXTERNAL SEMILUNAR CARTILAGE

A torn cartilage or a congenital disc cartilage may cause clicking (p. 205). With a disc cartilage the click, or thud, has a base pitch quite distinct from the treble "vacuum" click.

CLICKING TENDONS

Biceps Tendon. The tendon of the biceps femoris is inserted into the lower part of the outer surface of the head of the fibula. It is separated from the upper part of the head by a bursa and normally it slips smoothly backwards and forwards. When clicking is present the tendon catches on the bone and flicks across causing pain with each movement of flexion and extension. The click can be both heard and felt. The treatment is to fix the tendon to the underlying bone; this gives complete relief from symptoms and causes no disability.

Popliteus Tendon. The tendon of the popliteus muscle may slip in and out of its groove on the lateral condyle of the femur making an audible and palpable click. It is difficult to fix the tendon firmly in the groove without interfering with the function of the knee, but relief from symptoms is given by chiselling away the raised border of the groove to allow the tendon freedom of movement.

Joint Capsule. The joint capsule, or more properly the extensor expansion of the quadriceps muscle, may occasionally click over some small protuberance on the anterior part of one or other of the condyles of the femur. It is cured by removal of the protuberance.

With all clicking joints it is an advantage to operate with local anæsthesia because the mechanism of the click can then be demonstrated by the active movements of the patient.

Symptoms

Pain is the chief complaint. At first it is well localized, usually at the inner border of the foot, and it is perhaps felt only when tired and is relieved by rest. Later it becomes nearly constant, it is aggravated by weight-bearing, and it often radiates widely over the foot and calf. There may be some superficial œdema of the foot and ankle which gets worse towards the end of the day and disappears during the night.

On examination, there is usually, but not invariably, tenderness on pressure over the affected ligaments; there is limitation of passive movement in at least one direction, and pain at the extreme of that movement. X-rays are negative except when there is arthritis. The presence of minor *deformities is of importance only in so far as they may be causing the foot* to be mis-used in such a way as to place undue strain on the ligaments.

Treatment

The pain is due to tension on abnormal ligaments and consequently there are two ways of relieving it—support the foot to prevent tension, or restore the ligaments to normal.

Arch Supports. These are used with the intention of preventing the foot everting, and of taking the weight of the body instead of allowing it to fall on the ligaments. Although they have certain uses, they are generally pernicious instruments because they prop up the foot in replacement of the muscles whose job it is and give the muscles no chance to recover. In time, movement is restricted still further, the feet become stiffer and finally supports cease to be of use.

Supports may legitimately be prescribed as a temporary measure when there is no ligamentous damage. The type of patient they help is the shop assistant whose feet ache after standing all day, but they should be worn only whilst at work, and only until muscle function has been restored. Supports may have to be used permanently when the muscles are unequal to the task imposed on them, as with very heavy people, and also when there is chronic arthritis and it is impossible to restore movement.

Supports should be light in weight and yet of a material strong enough to keep shape. Duralumin is satisfactory but a covering of felt or sponge rubber is desirable if the feet are tender. An accurate fit is essential, and although a stock size can sometimes be used, supports often have to be made specially. They should be shaped to the pattern of a plaster cast made whilst the foot is held in the corrected position, and the common practice of taking a cast whilst bearing weight in the valgus position, or of making the support to the shape of a footprint on a piece of paper, is unsatisfactory.

Manipulation. The purpose is to restore movement when it is restricted by new and painful scar tissue which has formed as the result of gross injury, repeated minor traumata or disease. Manipulation is not intended, as is often erroneously stated, "to break down the arch" of a

"FLAT FOOT"

Different complaints are too frequently labelled "flat foot," but the confusion can be eliminated by appreciation that "flat foot" is a physical sign and not a diagnosis. A foot that looks flat is almost invariably a valgus foot, and since pes valgus is a postural defect, it is discussed with other postural defects in Chap. I (p. 23).

It cannot be over-emphasized that pes valgus is not ordinarily a painful condition. Pain in a foot that happens to be valgus should not straight away be attributed to the posture but the real cause determined; this may be any of the conditions that cause painful feet, for example, hallux valgus, anterior metatarsalgia or plantar fasciitis.

When the pain is directly associated with the posture one of the following conditions is likely to be present :—

1. Chronic Foot Strain. This is a disorder occurring in adults, but very seldom in children, in which pain is caused by a *change* in posture from "normal" to valgus. It is further discussed below.

2. Peroneo-Extensor Spasm, or "Spasmodic Flat Foot." This is a complaint of adolescents although symptoms may persist into adult life. It is described on p. 252.

3. Talo-Calcaneal Synostosis, a rare condition caused by a congenital structural anomaly (p. 255).

CHRONIC FOOT STRAIN

Restriction of movement at the inter-tarsal and tarso-metatarsal joints is a common cause of pain. The ability of the foot to resist the strain imposed on it depends on its resilience ; the muscles allow it to yield as it receives the body weight and then impart the spring that carries it to the next step. The ligaments of a supple foot are not under tension during ordinary movements and therefore a supple foot is seldom painful; but when movements are restricted, even slightly restricted, by reason of injury or disease, the ligaments are exposed to strain.

The muscles, not only the muscles of the foot but all the extensors of the legs and trunk, relax when they are fatigued from such causes as prolonged and unaccustomed standing, a rapid increase in body weight, a long illness, and sometimes a short acute illness. The foot then rotates into the valgus position under the influence of the body weight, and provided there is normal mobility, the inner border of the foot rests nearly on the ground without placing much strain on the ligaments (Fig. 15, p. 17) ; this may give rise to some tiredness and aching but not to any considerable pain. If, however, the foot is unable to rotate into valgus, the strain is taken by the ligaments and pain is caused.

Mobility is the key to the problem of this type of painful foot. A supple foot, whatever its habitual posture, seldom causes serious trouble ; but a stiff foot, whether it is stiff because of an unresolved sprain, arthritis, or contraction of the ligaments, is liable to become painful when subjected to strain. The stiffer the foot, the smaller the range of movements and the greater the risk of pain.

portion, perhaps one-third, of all cases. The symptoms are identical when there is a bar and when there is not.

(*b*) Sprain of the talo-calcaneal interosseous ligament; an injection of novocain into the ligament will then relieve the spasm.

(*c*) Erosion of the articular cartilage covering the talo-calcaneal or talo-navicular joints; this has occasionally been seen at operation.





Fig 182 Peroneo-extensor spasm in a boy aged 16 years, with a complete calcaneo-navicular bar in the left foot The right foot was normal

Calcaneo-navicular Bar is a congenital anomaly in which the calcaneus and the navicular bones are joined together by a complete or partial bridge of bone (Fig. 182). It is probably due to an unusual degree of development of an accessory bone, the os calcaneus secondarius, that is present in some 2 per cent of people (p. 301). The anomaly can be demonstrated only in oblique radiographs, and it should be sought whenever there is peroneo-extensor spasm.

A calcaneo-navicular bar does not necessarily affect the shape of the foot or cause symptoms. Indeed, it is probable that many feet with such a bar remain normal throughout life. It appears, however, that the presence of the bar alters the mechanics of the foot making it more liable to strain, and then the increased stresses to which the feet are subjected during adolescence precipitate the onset of symptoms.

contracted foot. The force used should be sufficient to tear new scar tiss but inadequate to injure the ligaments.

The indication for manipulation is pain at the extreme of active passive movements at one or more joints. Generally speaking the m supple the foot, the better the prognosis. When there is chronic arthr it may be possible to restore a useful range of painless movements, but i better to repeat a gentle manipulation several times than to be so viol as to produce a severe reaction.



FIG 181 Manipulation of the foot—distraction of the subtaloid and ankle joints

An anæsthetic is generally required for manipulation. The foot is moved into full inversion and eversion, plantar- and dorsi-flexion. The method of distracting the subtaloid and ankle joints is illustrated in Fig. 181 : the patient's knee is flexed to shorten the distance between the thigh and heel and at the same time the operator's wrist is straightened.

After treatment consists in massage and active and passive movements continued until the injury has resolved. Proper muscle control is taught, and attention is given to any minor deformity or other condition that may have played a part in producing the strain.

PERONEO-EXTENSOR SPASM

(*Synonym*) Spasmodic Flat Foot

This is a fairly common syndrome in which the foot is held rigidly in a position of valgus by spasm of the peroneal muscles and the long extensors of the toes. Early diagnosis is important and yet many doctors fail to recognize the presence of spasm, apparently because they have the mistaken idea that "flat foot" is a diagnosis and do not make a full examination.

The ætiology is not fully understood. Although it is clear that the spasm is a reflex phenomenon, the cause varies and can be determined only in a minority of patients. Amongst the possible causes are :

(*a*) A calcaneo-navicular bar which is present in ... large pro-

TALO-CALCANEAL SYNOSTOSIS

This rare complaint is not classified with peroneo-extensor spasm, although an extreme valgus position of the foot is a characteristic feature, because the course and treatment are different. A rigid valgus foot is present early in life but spasm is seldom seen before adult age; conservative treatment is valueless.

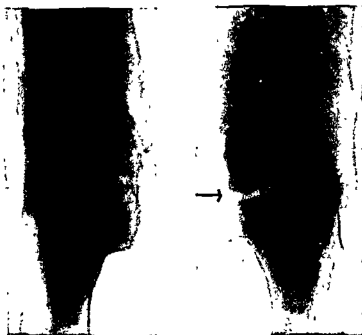


FIG 183 Talo-calcaneal bar
Left X-ray of the left foot of the patient illustrated in Fig 184, showing talo-calcaneal synostosis
Right X-ray of a normal right foot for comparison The arrow points to the joint between the talus and the calcaneus at the level of the sustentaculum tali

The anomaly was first described by anatomists long ago, and the clinical condition also has been known for many years, but the two were correlated only in 1948 by R. I. Harris. It consists of a bridge of bone joining the posterior aspect of the sustentaculum tali of the calcaneus to the inner surface of the talus (Fig. 183). The bridge may be complete (synostosis), or it may be interrupted by a fibrous band (syndesmosis), or by a cartilaginous band (synchondrosis). It can be demonstrated radiologically by an oblique projection with the patient standing on the film with the knees slightly bent and the tube above the heels and pointing forwards 45°. In addition to the chief defect there is almost invariably lipping of the dorsal aspect of the talo-navicular joint, and sometimes a small ossicle is present at this site.

Clinical Features

The presence of a bridge joining the talus and the calcaneus makes all movement between these bones impossible and therefore the normal

Clinical Features

The acute phase occurs in adolescents of about fourteen to seventeen years of age, occasionally in younger children and only rarely in adults. It may be unilateral or bilateral, and boys are affected more often than girls. The onset is usually soon after starting work, or changing to an occupation involving standing or walking on a hard surface, hence the complaint is sometimes known as "apprentice's foot."

Pain is the chief complaint. At first it may be felt only towards the end of the day but it rapidly increases until walking, standing and bicycling are all painful. The foot is held in eversion and dorsiflexion by spasm of the affected muscles, and the long extensors stand out prominently in front of the ankle. Attempts to invert the foot passively increase the pain and spasm; sometimes the spasm can be inhibited voluntarily, but often it does not disappear entirely even during deep anæsthesia. X-rays may show a calcaneo-navicular bar, and at a late stage there is often lipping of the dorsal aspect of the talo-navicular joint.

Diagnosis must be made early because only then is there a chance of successful conservative treatment. In an untreated or unsuccessfully treated case, the deformity is permanent; pain and spasm may gradually decrease and finally disappear entirely, but within a few years osteoarthritic changes take place in the distorted joints and pain returns.

Treatment

Treatment, to be successful, must be begun within a few weeks of onset; it is a waste of time after months. A light plaster is applied in the neutral, plantigrade position, an anæsthetic being given if relaxation cannot otherwise be obtained. Weight-bearing, even in plaster, is prohibited, but crutches may be used when only one foot is affected. The plaster is removed after two months and if there is then no spasm, massage and exercises are commenced, but weight-bearing is avoided for a further month; if the spasm returns, the plaster is re-applied.

An injection of proctocain into the talo-calcaneal interosseous ligament sometimes relieves the spasm, presumably when this ligament happens to be the source of irritation (Ellis). The needle is inserted about one inch below and in front of the internal malleolus and directed backwards and outwards into the sinus tarsi.

Operation. In adolescents, when conservative treatment has failed, or when the diagnosis has been made late, it is worth while excising the bar because this quite often gives relief. The approach is from the inner side of the foot and care is necessary as it is not easy to remove the entire bar without causing unnecessary damage.

The late symptoms in adults, and in younger people who have not been helped by excision of the bar, can be relieved by arthrodesis of the talo-calcaneal and talo-navicular joints. This is readily achieved, except when there is gross deformity, by inserting cancellous bone grafts into slots cut across the joints.

PAIN IN THE FOREFOOT

The forefoot is the site of pain in at least three-quarters of all adult patients complaining of pain in the foot. The reverse holds in children and adolescents who seldom have pain on the forefoot.

The causes of pain in the forefoot are:—

Outer four toes.	Anterior metatarsalgia.	*Big toe.*	Sesamoiditis.
	Morton's metatarsalgia.		Lipoma.
	March fracture.		
	Osteochondritis.		

Anterior metatarsalgia, a condition affecting the metatarso-phalangeal joints, is the usual cause of pain in the forefoot, and it must be sharply distinguished from Morton's metatarsalgia in which the pain is referred over the distribution of the digital nerves. Pain under the big toe is not due to the ordinary type of anterior metatarsalgia but is usually associated with disorder of the sesamoid bones.

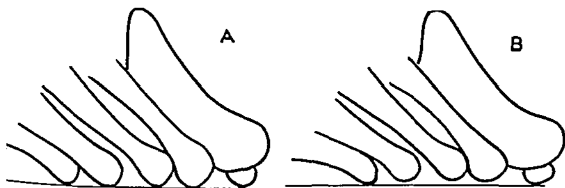


FIG 185. Tracings of the radiographs of a foot (A) when bearing weight, and (B) with no weight on it

Anterior metatarsal pain is sometimes said to be due to stretching of the transverse metatarsal ligament, presumably because a splayed forefoot is often painful. The evidence, however, is against this theory: the pain is felt when wearing shoes tight enough to prevent the forefoot spreading, it is not increased by pulling apart the metatarsal heads, and the tenderness is over the metatarso-phalangeal joints, not over the interosseous spaces.

ANTERIOR METATARSALGIA

The Transverse Arch. In cross-section the metatarsal and mid-tarsal bones are arranged in the shape of an arch which is highest at the base of the metatarsals, and gradually becomes more shallow until at the level of the metatarsal heads it has almost disappeared. It must be accepted as an anatomical fact that in normal circumstances there is no transverse arch at the level of the metatarsal heads, and although there may be a slight upward curve when the foot is not bearing weight, the metatarsal heads certainly lie in the same horizontal plane when standing (Fig. 185). On the other hand, in some pathological conditions the line of the metatarsal heads becomes convex downwards.

movements of inversion and eversion are absent (p. 19). Deformity is probably slight in infancy but it increases during growth as the bridge gets longer and the calcaneus is forced into eversion; by the time growth is complete the foot is in a position of extreme valgus and the navicular and the head of the talus form a prominent bulge on the inner border (Fig. 184).

Symptoms are unusual until adolescence or early adult life and then they resemble those of peroneo-extensor spasm. The onset is precipitated by unaccustomed use of the foot, e.g. marching; pain is felt whilst using the foot, and there is spasm of the peroneal muscles and the extensors of the toes. The diagnosis depends on the appearance of the foot, the length of the history and the X-ray findings.



FIG 184 "Flat foot" due to talocalcaneal synostosis (cf Fig 182) The feet had been abnormal in shape since early childhood but there were no symptoms until the age of 23

Treatment

Conservative treatment is without effect because the abnormal structure of the bones prevents correction of the deformity by any simple [illegible] indefinitely. The operation is successful in relieving pain; it is, however, technically difficult because of the presence of abnormal bar of bone and the great distortion of the tarsus, and it is not always possible to restore the shape of the foot to normal.

varus to avoid pressure on the painful spot; pressure on a painful corn may be avoided by deliberately curling up the toes; a hammer toe may depress a single metatarsal head below the level of its fellows; inability to dorsiflex the big toe (hallux rigidus) compels the weight to be transferred to the outer border of the foot; or a short first metatarsal may cause too much weight to be taken by the second metatarsal which is not suitably constructed for this purpose.

Trauma. Sometimes a specific injury can be blamed for the onset of metatarsalgia, for example treading heavily on a small stone when walking in thin-soled shoes.

Unsuitable Shoes. Shoes that are too short cause the toes to be curled up, and those that are too tight may cause corns, or they may force the metatarsal heads into a curve, convex downwards. The most harmful



FIG. 186 A high-heeled shoe should have a nearly horizontal platform on which the heel can rest

shoes are those constructed with a high heel and no platform on which the weight can rest; there is then an inclined plane sloping from the back of the heel to the tread and the foot slides forwards crushing the metatarsal heads together and curling up the toes (Fig. 186). It is not the height of the heel that matters, but the absence of a platform to rest on.

Symptoms and Signs

Anterior metatarsalgia occurs at any age but most often in middle life when there is a tendency for muscle tone to decrease. Any of the outer four metatarso-phalangeal joints may be affected, and often more than one at a time. The onset is usually gradual, but it may be sudden when caused by a definite minor injury, or by wearing new shoes. Pain is felt first in the affected joints, but later it radiates over the foot and sometimes up the calf. I

worse

On examination, there is tenderness over the distal aspect of the affected metatarsal head when it is uncovered by dorsiflexion of the toe, and often over the plantar and dorsal aspects also. Acute pain is caused by passive plantar flexion of the metatarso-phalangeal joint. There may be swelling of the joint visible on the dorsum of the foot, and perhaps some superficial œdema. In old-standing cases the ball of the foot becomes convex and painful callous forms under the prominent part (Fig. 187). Absence of the normal longitudinal crease between the first and second metatarsals is a constant finding when there is long-standing intrinsic muscle dysfunction.

Ætiology

Anterior metatarsalgia is a painful condition affecting one or more c the outer four metatarso-phalangeal joints, and it is usually caused b faulty distribution of weight on the forefoot.

The first metatarsal bone is large and strong, and the metatarso phalangeal joint is protected by two sesamoid bones. The four oute metatarsals are slender bones, ill-adapted for carrying weight; th metatarso-phalangeal joints are correspondingly small and do not usuall have sesamoids. The whole body weight does not ordinarily rest on th outer metatarsals alone. When walking the weight is transferred from th heel to the outer border of the forefoot and then immediately to the inne border; during the phase of "take-off" it is mostly carried by the big to When standing, the outer metatarsals assist in keeping the balance but d not take much of the weight. If for any reason an excessive amount c weight is habitually carried on the outer metatarsals, these ill-protecte joints are injured. The joint capsule, synovial membrane and articula cartilage are bruised, and in time chronic inflammatory changes take plac the capsule becomes thickened and the periarticular tissues inflamed.

The principle causes of faulty distribution of weight in the forefoo are :—

Intrinsic muscle dysfunction.
Minor deformities of the foot.
Trauma.
Unsuitable shoes.

Intrinsic Muscle Dysfunction. The interosseous muscles functio in such a way as to protect the metatarso-phalangeal joints. When the contract they flex the metatarso-phalangeal joints and extend the inte phalangeal, and in addition they draw together the metatarsal heads, a action which is re-inforced by the transverse muscles. The inteross contract during the final phase of each step and prevent the forefoo splaying as the weight comes onto it, and they prevent the toes curling u when the long flexors and extensors contract (p. 266). Failure of the intrins muscles therefore permits two defects to develop—the forefoot spreads an the toes curl up. When the toes are curled up, the proximal phalanges a above the metatarsal heads and pointing upwards; the metatarsal hea are therefore forced downwards making them more prominent in the ba of the foot, and more exposed to trauma.

Intrinsic dysfunction is nearly always present in anterior metatarsalg either as the cause, or as the result. It is the cause in such conditions pes cavus, hallux valgus, or muscular weakness following a long illnes It is the result because the conscious reaction to anterior metatarsal pain whatever origin is to curl the toes in an endeavour to lift the metatars heads from the ground, and to do this the intrinsics must be inhibited.

Minor Deformities. These interfere with the proper distribution weight in a number of ways of which the following are examples. Whe the deformity, say a bunion, is itself n [illegible] the foot [illegible] be twisted int

tional exercises, which are still practised in many clinics, make use of quite the wrong muscles.

The patient should be taught to contract the interosseous muscles each time the forefoot touches the ground. First he acquires voluntary control over the muscles; with the foot flat on the ground, the effort is made to lift the central metatarsal heads without curling the toes, and without raising the inner border of the foot. When the movement is made properly the forefoot becomes narrower, the toes extend at the interphalangeal joints and flex at the metatarso-phalangeal joints, and the central metatarsal heads are slightly raised (*Fig.* 189). Once there is complete voluntary control it is not difficult to learn to contract the muscles at each step immediately the ball of the foot touches the ground, and after a time the action becomes reflex.

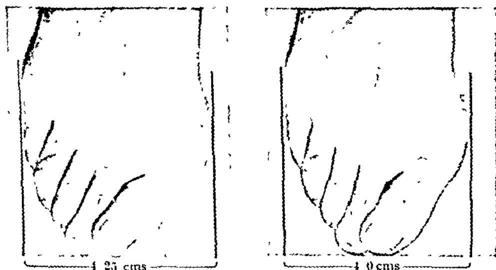


FIG 189 Contraction of the interosseous muscles makes the forefoot narrower and lifts up the middle three metatarsal heads The illustration is about one quarter scale showing that the foot has become 1 cm narrower

Other exercises are better avoided, particularly those making use of the long muscles which cause the toes to curl; they are not essential and patients so often do the easy exercises regularly and forget the harder ones. The object of treatment is to condition a reflex and the patient's attention should be directed towards this alone.

MORTON'S METATARSALGIA

T. B. Morton in 1876 described a form of metatarsalgia which he attributed to the digital branches of the plantar nerves being crushed between the metatarsal heads. For many years afterwards all types of metatarsalgia were included in this category but the true syndrome is relatively uncommon and the diagnosis fell into disrepute. It was only when Betts described the true pathology in 1940 that attention was again directed to the problem, and since then the work of Bickel and Dockerty and of Nissen have placed it beyond doubt.

The underlying pathological condition is an enlargement of one of the plantar digital nerves. The swelling is usually about half an inch in length

Treatment

The painful joints respond, as elsewhere in the body, to rest and physiotherapy. Recurrence is, however, probable unless the primary cause can be removed and this is possible in many instances, specially when there is a deformity that can be corrected by operation.

Patients with severe pain and swollen joints need an initial period of rest in bed. Milder symptoms are often relieved by a pad of thick chiropodists' felt (zinc oxide felt plaster) placed immediately proximal to the painful joints, not beneath them (Fig. 188). The pad should be about two-thirds the breadth of the foot, cut square in front and tapered behind; the front edge is left vertical but the others are chamfered. The forefoot and



FIG 187 Hallux valgus with intrinsic muscle dysfunction The ball of the foot is convex and there is metatarsalgia affecting the second third and fourth metatarso phalangeal joints



FIG 188 To relieve pressure on the metatarso-phalangeal joints, a pad of zinc oxide felt plaster is placed immediately *proximal* to them

pad are encircled firmly, but not tightly, with a strip of one-inch adhesi plaster. An elastic garter with pad attached, or an insole with an anteri metatarsal pad, are used when a permanent fitting is required.

Intrinsic muscle re-education is an essential part of treatment an cure is unlikely unless proper muscle function can be restored. Whe operative correction of a deformity is necessary, re-education shoul precede as well as follow operation. Re-education is not very difficul except when the foot is grossly mis-shapen, but unfor[illegible]ely the trad



FIG 191 March fracture of the third metatarsal

On examination, there is tenderness which is accurately localized to some part of the shaft of the metatarsal (*not* the metatarso-phalangeal joint), and there may be œdema of the dorsum of the foot. The clinical finding of tenderness over the shaft of a metatarsal is sufficient to demand X-ray examination, and if no bony change is shown at the first examination, it should be repeated after a week or two.

The radiological appearance depends on the stage at which examination is made. For a few days after the onset of symptoms the bone looks normal; the first change is a little roughening of the metatarsal shaft, and during the next few weeks a fusiform deposit of new bone is laid down. Usually, but not invariably, a line of "fracture" runs across the metatarsal, and occasionally across the new bone also; sometimes the "fracture" can be distinguished before the new bone appears, but often not till afterwards. The final appearance is that of a transverse fracture in perfect position with profuse callus formation (Fig. 191).

Treatment. There is no tendency to displacement of the "fracture" and splinting is unnecessary. If the pain is severe, complete rest from weight-bearing may be necessary for a week or two, but it is usually sufficient to strap the foot firmly and avoid excessive walking. The symptoms subside spontaneously in three to six weeks from the time new bone is first seen and full activity can then be resumed. Radiological return to normal takes much longer and need not be awaited.

and an eighth of an inch in thickness (Fig. 190). Microscopic examination at an early stage shows considerable perineural œdema and proliferation of the neurilemma cells, and later this is followed by interstitial fibrosis. There are also changes in the plantar digital vessels and these changes precede those in the nerve. Nissen considers the lesion in the nerve to be ischæmic and occurring secondarily to primary vascular degeneration; the spasms of pain may be due to ischæmia.

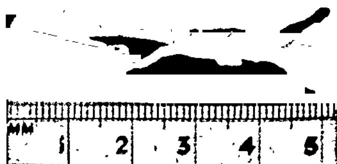


FIG 190 "Neuroma" of the third plantar digital nerve (by courtesy of Mr. K. I. Nissen)

The outstanding clinical feature is pain which occurs in attacks, the foot being relatively normal between attacks. The pain shoots to the tip of a toe or two adjacent toes, usually the third and fourth, but occasionally the second and third. An attack often starts with a burning sensation around the metatarsal heads and develops rapidly until it is really severe and radiates widely; the patient may describe it as being like "cramp" or "neuralgia". The attacks occur at any time but usually when wearing shoes. Relief is often given by removing the shoe and rubbing the foot, and when a patient admits doing this in the street, the diagnosis is fairly certain. On examination, the ordinary signs of metatarsalgia, such as tenderness over the affected metatarsal heads, are absent. Pressure with a blunt instrument between the third and fourth metatarsals about one inch proximal to the webb of the toes causes pain which the patient recognizes as similar to the pain he is complaining of.

Treatment. Conservative treatment is useless. The only method of giving relief is to excise the affected portion of the nerve and the results of this are highly satisfactory.

MARCH FRACTURE

(*Synonym*) Stress Fracture

This is a peculiar condition that is probably analogous to stress fracture of the tibia, the femoral neck and other bones. The pathology is not understood but it is possibly associated with some disturbance of the main nutrient vessel to the bone.

March fracture is common in soldiers, and in civilians it is seen chiefly amongst those who do a lot of walking, for example hospital nurses. Any of the outer four metatarsals may be affected, but usually the second or third. The patient complains of pain in the anterior metatarsal region.

PAIN UNDER THE BIG TOE

The Sesamoids. The ordinary type of anterior metatarsalgia does not occur at the first metatarso-phalangeal joint because it is protected by two sesamoid bones. Pain does, however, arise in connection with the sesamoids, even in the absence of deformity of the big toe. The trouble is frequently traumatic and then it may be caused by a minor injury like treading on a loose stone. Osteoarthritis of the joint between the sesamoids and the metatarsal head is also a common cause of pain.

The pain, sometimes very severe, is felt under the joint when walking. Tenderness can be localized to one or other of the sesamoid bones by careful palpation. X-rays may be misleading because fracture of a sesamoid is rare, but symptomless congenital abnormalities in which the bone is divided into two or more parts (bipartite or tripartite sesamoids) are common and then the appearance somewhat resembles a fracture (Fig. 193).

Conservative treatment of painful sesamoids is usually successful, but often very slow. Little more can be done than relieve pressure by a felt pad placed proximal to the joint, but diathermy sometimes appears helpful. Occasionally it is necessary to excise one of the sesamoids. When it is necessary to remove both bones, and this is rare, it is desirable to arthrodese the metatarso-phalangeal joint as well; the protection of a felt or sorbo pad is necessary for a very long time whilst a fibro-fatty pad is forming.

Lipoma. A tender and painful lipoma is sometimes found in the subcutaneous tissues under the first metatarsal head. It is usually encapsulated and readily removed; its importance lies in the fact that it displaces the normal fibro-fatty tissue and, after removal, nothing is left but skin to cover the joint. The thick subcutaneous tissues act as a shock-absorber and without this covering the joint soon becomes painful; a cupped sorbo pad should be worn until the subcutaneous tissues have re-formed.

OSTEOCHONDRITIS OF THE NAVICULAR

(*Synonym*) Köhler's Disease

This condition resembles osteochondritis juvenilis in other bones and probably has a similar pathology (p. 167). It occurs more frequently in boys than girls, and at any age between three and ten years with a maximum incidence from four to six years. It is occasionally bilateral. The child complains of pain at the inner side of the foot, and he limps. On examination, there is tenderness over the navicular bone and sometimes a little swelling.

Similar symptoms occurring in older children or adults may be due to the presence of an accessory bone situated at the tuberosity of the navicular (*os tibiale externum*), or to strain of the insertion of the tendon of the tibialis posterior.

The X-ray changes in Kohler's disease are characteristic (Fig. 194). The centre of ossification is increased in density, it is often irregular in

OSTEOCHONDRITIS OF THE METATARSAL HEADS

(*Synonyms*) Freiberg's Disease, Köhler's Second Disease

This is an uncommon complaint which affects the metatarsal heads, most frequently the second, less often the third and rarely the others. Many writers consider the condition belongs to the group exemplified by Perthes disease of the hip, but others think it is similar to osteochondritis dissecans of the knee. It is probable that both are right and there are really two varieties of the disease.



FIG 192 Osteochondritis of the second metatarsal head of the usual type



FIG. 193. Osteochondritis of the second metatarsal head. At operation a condition was found that resembled osteochondritis dissecans

The onset is during adolescence and the symptoms are pain, tenderness, stiffness and swelling of the metatarso-phalangeal joint. The X-rays at first show irregular areas of condensation and rarefaction in the epiphysis. The contour of the head gradually alters; it becomes broader and the outline of tl [illegible] metatarsal [illegible] (Fig. 192). In the type resembling osteochondritis dissecans (Fig. 193) an area of articular cartilage and the underlying bone separate and may become detached to form a loo[illegible]

Treatment. [illegible] start with, but late[illegible] while, but if osteoarthritic changes take place later, the toe becomes stiff and the pain returns. It may then be necessary to excise the [illegible]tarsal head.

the interossei; the metatarsophalangeal joints are flexed by the interossei and extended by the long extensors (Fig. 282, p. 377). Normally, these muscles function synergically, the intrinsics preventing flexion at the interphalangeal joints when the long flexors contract during the "take off" phase in walking. If the intrinsics are inadequate, the long muscles are unopposed and the toes become clawed; the proximal phalanges, which then point more or less directly upwards, are displaced on to the dorsum of the metatarsal heads, and the latter are forced downwards.

An external torsional deformity of the tibia is often associated with pes cavus, particularly when the onset is early (p. 26). It can be so extreme that the external malleolus is situated almost behind the internal.

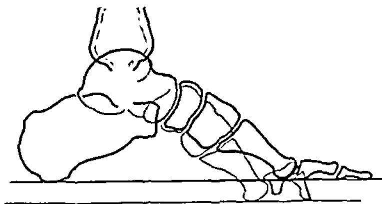


FIG 195 The deformity in pes cavus is often due to dropping of the forefoot, the posterior part remaining normal.

An uncommon but severe type of pes cavus, usually without clawing of the toes but accompanied by changes in shape of the posterior part of the foot, is caused by paralysis of the triceps suræ. The foot is drawn into strong dorsiflexion at the ankle by the unopposed action of the extensors; the calcaneus is distorted and points obliquely upwards, and the forefoot is angled sharply downwards at the inter-tarsal joints.

Symptoms

The "idiopathic" type usually starts during childhood, and the first sign is clawing of the toes, sometimes of the big toe only, but often of all the toes. It is impossible to give a prognosis at this stage; there may be spontaneous arrest with only trivial deformity, or there may be steady deterioration until growth is complete. At first the deformity can be corrected passively, but in time the muscles and fascia in the sole of the foot and on the plantar aspect of the toes contract and the deformity becomes fixed (Fig. 196). When the deformity is severe it is impossible to dorsiflex the ankle sufficiently to get the heel to the ground. The toes are sometimes dislocated dorsally at the metatarso-phalangeal joints.

There is seldom pain in childhood but complaint may be made of the rapidity with which shoes are worn out. At a later stage pain is caused by the abnormal amount of pressure that has to be taken by the ball of the foot. This causes severe anterior metatarsalgia, and most intractable corns and callosities develop on the dorsum of the toes and under the

outline, and it may be divided into two or more parts. The bone appears to be flattened and compressed antero-posteriorly.

Treatment. The disease runs a course lasting from one to two years after which the structure of the bone returns to normal. There may be some permanent distortion of shape but this does not appear to cause later symptoms. Treatment has no effect on the course and the pain nearly always subsides spontaneously within a few months even though the radiological appearances remain abnormal.



FIG 194 Kohler's disease of the tarsal scaphoid. *Left*. Shortly after the onset of symptoms *Right* Ten months later.

Some relief from pain is given by strapping the foot in inversion. Walking and games should be avoided as far as possible, but it is seldom necessary to keep the child from school. Occasionally the pain is severe enough to call for a walking plaster. Normal use of the foot is permitted as soon as the symptoms have subsided.

PES CAVUS AND CLAW TOES

Pes cavus in most instances is accompanied by clawing of all the toes, including the big toe. The high-arched appearance is due not so much to true raising of the arch as to dropping of the forefoot at the inter-tarsal and tarso-metatarsal joints. The posterior part of the foot is normal and the calcaneus is in its ordinary position relative to the talus and tibia (Fig. 195).

The cause, as was recognized many years ago by Duchenne, is to be found in dysfunction or paralysis of the interosseous and lumbrical muscles, and the short flexors and abductors of the big toe. This may be due to disease of the central nervous system, for example anterior poliomyelitis, the hereditary ataxias and peripheral nerve injuries. As a rule, however, it is not caused by gross disease, but by lack of proper co-ordination of the intrinsic muscles (*idiopathic type*).

The mechanism by which the deformity is produced is as follows: the interphalangeal joints are flexed by the long flexors - tended by

little inconvenience, and as a rule the cavus gradually disappears and the foot returns to a normal shape. Rotation osteotomy of the tibia is occasionally necessary when there is a severe torsional deformity.

The operation is satisfactory in children and adolescents but less so in adults because the tarsal bones are unable to adapt themselves to their altered positions. It is contra-indicated when there is actual dislocation at the metatarso-phalangeal joints. When the deformity is slight and affects only the inner border of the foot, it may be sufficient to arthrodese the interphalangeal joint of the big toe only.

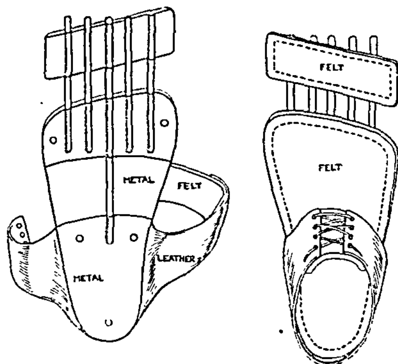


FIG 197 Sole plate for use after Lambrinudi's operation (Reproduced by permission from Burns and Ellis "Recent Advances in Orthopædics")

Bony union at the small terminal interphalangeal joints is not easy to obtain but Lambrinudi's technique gives a high percentage of successes. After simple transverse excision of each joint, the toes are fastened to a special sole plate by salmon-gut stitches passed around the proximal phalanges and emerging through the skin of the plantar surface just distal to the web (Fig. 197). The stitches are left for six weeks and then all fixation is removed and walking commenced. Rehabilitation is slow and it may be six to twelve months before walking is normal.

STEINDLER's operation consists in detaching the muscles, ligaments and fascia arising from the calcaneus and straightening the foot with a Thomas's wrench; the muscles slide forwards and re-attach themselves more distally. The operation gives a good immediate result and the period of incapacity is short, but recurrence of deformity is common because the cause is not removed. Sometimes it can usefully be combined with Lambrinudi's operation.

metatarsal heads. There may also be pain in the mid-tarsal region caused by the strain on that part of the foot.

In adults, the gradual development of pes cavus is usually indicative of the onset of disease of the central nervous system. The recognition of this is important because all forms of operative treatment may be contra-indicated (except in Friedreich's ataxia developing during adolescence when operation is often helpful (p. 522).

Treatment

In the "idiopathic" type, before the deformity is fixed, it may be possible to arrest progress by re-educating intrinsic muscle function by the method described for anterior metatarsalgia (p. 260). Shoes without heels, but having stout leather soles, should be worn to force up the forefeet.

After the deformity is fixed, treatment may be palliative or operative—either shoes are made to fit the feet, or the feet are made to fit ordinary shoes.

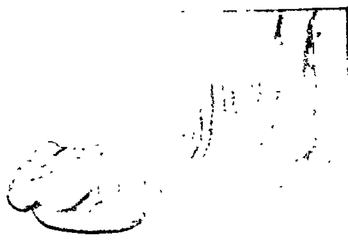


FIG 196 Pes cavus in a boy aged 14 years.

Footwear. Special shoes will not arrest the development of th progressive type of disease but they do give tolerable comfort to mos patients. They must be made with ample room both for the deformed toe and for a moulded cork insole. The insole should be thick enough at th heel to allow for the dropped forefoot, curved to fit the instep, and have slight thickening to take the pressure just proximal to the metatarsal heads. A steel inserted between the welt and sole may prevent the sole of th shoe from arching and breaking.

Operation. An operation, to be satisfactory, should both correct th existing def[illegible]

[1] LAMBR[illegible]

to fulfil thes[illegible]

geal joints c[illegible]

the long flexors and extensors is transferred from the interphalangeal to th metatarso-phalangeal joints; clawing is corrected, the toes are restore to their proper alignment with the metatarsals and downward thrust o the metatarsal heads is eliminated. The stiff interphalangeal joints caus

Factors tending to increase the deformity after deflection of the toe has commenced are (1) the direction of thrust when walking with the foot turned slightly outwards, (2) wearing shoes, because this removes the need for the "gripping" action of the toes which is present when barefooted, (3) displacement of the flexor and extensor tendons towards the outer side of the metatarso-phalangeal joint thus making their pull eccentric.

Pathological Anatomy

The principal features are :—

1. Varus (or inward) deflection of the first metatarsal at the tarso-metatarsal joint; it is usually pronounced in familial cases and is often present in others. Not infrequently the outer four metatarsals are also

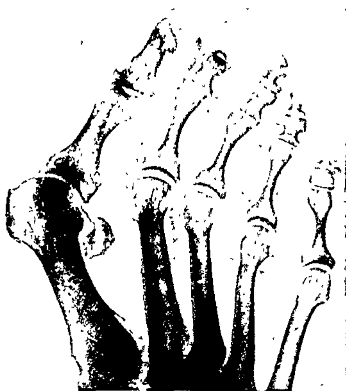


Fig 199 Hallux valgus Note the varus deformity of the first metatarsal

deflected inwards, but to a lesser extent than the first. The gap between first and second metatarsals is filled with fibro-fatty tissue (Fig. 199).

2. Valgus (or outward) deflection of the phalanges at the metatarso-phalangeal joint. Slight to start with, the displacement increases and sometimes reaches the extreme stage in which the phalanges form an angle of 90° with the first metatarsal and lie transversely across the proximal phalanges of the other toes. The joint capsule becomes lengthened on the inner side and contracted on the outer. The toe is often rotated inwards about its long axis, and sometimes there is also a valgus deformity at the interphalangeal joint, particularly when the joint abuts on a clawed second toe around which it appears to curl (Fig. 200).

HALLUX VALGUS

This is the commonest of all the deformities of the feet. A trivial degree is so often seen amongst adults of western races that it can hardly be called abnormal, but the more severe deformities give rise to much suffering.

The cause is difficult to determine. The condition is often familial and grandparents, parents and children may all be afflicted. Women are affected with much greater frequency than men, and if hereditary transmission does in fact occur, it appears to be chiefly, but not exclusively, on the female side. The metatarsus varus element of the deformity is usually pronounced in familial cases, and often the first metatarsal is short as well. It has been



...ng woman There is but only a moderate ..., the symptoms were restricted to the bunion

estimated that in about 5 per cent of patients the deformity is first noticeable in early childhood, and the percentage increases steadily until the 'teens.

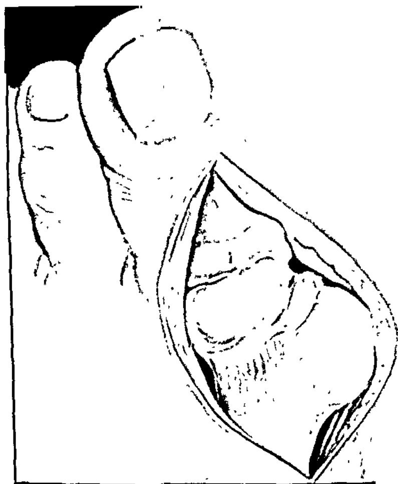
The classical explanation of hallux valgus is that the toes are pressed out of position by wearing tight or pointed shoes, or tight hose. In recent years there has been marked improvement in the design of children's footwear and an increasing awareness amongst parents of its importance, but no corresponding decrease in the incidence of hallux valgus. The footwe...

ver...

is s...

hallux valgus is uncommon in races that go unshod, and it might be that wearing shoes interferes with the natural use of the intrin... ...cles.

PLATE III



Hallux Valgus as displayed at operation.

3. The big toe may lie over or under the second toe, or the second toe may escape pressure by curling up. Soft corns and infection of the nail bed often occur where the toes are in contact. The second toe may be displaced upwards by the big toe to such an extent that it dislocates dorsally at the metatarso-phalangeal joint; this is quite a common occurrence and it can readily be detected on clinical examination (Fig. 200).

4. The extensor tendon is displaced towards the outer side of the metatarso-phalangeal joint. The sesamoids and the long flexor tendon, restrained by the adductor muscle from moving inwards with the first metatarsal, slip out of their grooves under the metatarsal head.

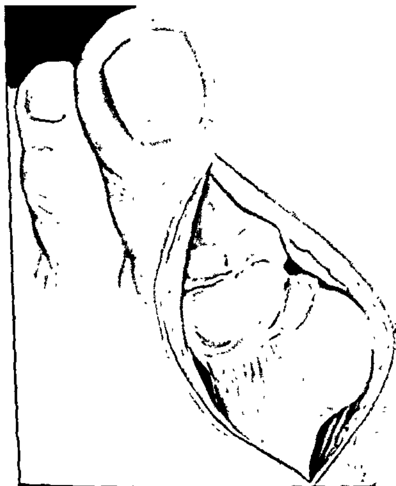


Fig. 200 Hallux valgus with dorsal dislocation of the metatarso-phalangeal joint of the second toe.

5. The articular cartilage covering the metatarsal head is eroded where it is exposed by displacement of the phalanx. There is often a groove forming a line of demarcation between the exposed and covered cartilage (Plate III). The inner side of the metatarsal head may be flattened and then the appearance somewhat resembles an exostosis (Fig. 199). There is, however, no true exostosis and the only new formation of bone consists of a small hyperostotic ring at the old articular margin.

6. A fibrous mass forms over the prominent bone, and superficial to this a bursa (or bunion) containing gelatinous material. A painful corn often forms in the overlying skin.

7. The deformity interferes with the proper function of the intrinsic muscles and the ball of the foot becomes convex giving rise to anterior metatarsalgia.



Hallux Valgus as displayed at operation.

[To face page 272

Symptoms

The pain does not vary pari passu with the severity of the deformity, and sometimes there is gross deviation of the toe with but little trouble whilst a minor degree may give rise to disabling pain. The symptoms are of two categories—those due to the bunion and those due to secondary deformities and metatarsalgia.

The bunion is painful when pressure and friction against the side of the shoe cause it to become inflamed; the bursa distends with fluid and often a small but very tender corn develops in the overlying skin. The amount of pain depends on these factors and not on the degree of deformity. Infection not infrequently follows a neglected abrasion or the patient's own attempts to remove the corn; the skin becomes inflamed and the bursa may suppurate, but only rarely does infection spread to the bone or joint.

Metatarsalgia and secondary deformities such as hammer toe may be the chief cause of the pain. They give rise to the same symptoms as when due to other causes. With old standing, severe deformities the forefoot is splayed, there are callosities under the metatarsal heads and corns on the dorsum of the toes, the spring is lost from the gait and the sufferer hobbles about in a painful and ungainly way.

Treatment

Conservative. Patients with symptoms limited to the bunion can often be kept free of pain. The corn is removed using an aseptic technique, and pads of zinc oxide felt plaster are arranged round the swelling to relieve pressure. The fluid is eventually absorbed and it may be possible to prevent further trouble by careful selection of footwear. "Bunion protectors," which can be obtained from many chiropodists, give good protection from pressure.

When the deformity is slight but metatarsalgia is pronounced, it is tempting to disregard the deformity and treat the metatarsalgia conservatively, but this is seldom successful until after the big toe has been straightened. In severe, old standing deformities the disorganization of function is such that nothing can restore the foot to normal; reasonable comfort can, however, be given by a combination of operation, metatarsal pads and special shoes.

Operation. This has a bad reputation amongst the public, but properly performed it gives consistently good results and brings more thanks to the surgeon than almost any other operation. It is really an arthroplasty, an arthroplasty of a weight-bearing joint, and yet there is a tendency to regard it as a minor procedure! Not only is a meticulous technique required, but equal care must be taken after operation to ensure that active movements of the toe are regained and the proper balance of the foot is restored. Careless work with some operations may mean only a few weeks longer spent in convalescence, but the unskilled correction of a hallux valgus leaves a cripple for life.

The indications for operation are:—

1. Pain due to pressure on the inner side of the joint.
2. Anterior metatarsal pain.
3. Painful deformities of the other toes.
4. Correction of metatarsus varus is sometimes desirable in childr

Operation should never be performed for cosmetic reasons alone ar careful selection of patients is important. A good result giving almo perfect function can be relied on when the general function of the foot good, but only partial relief is possible if the whole foot is grossly deformed between these extremes is a whole range of varying prognosis. Son judgement is necessary when deciding what benefit is likely to follo operation and it is wise to give the patient an accurate and not undul optimistic forecast.

The conservative operation of removing only the bunion and under lying exostosis is a comparatively minor proceeding but of limited applica tion. The bunion is dissected from the skin, the joint opened and the inne portion of the head of the metatarsal removed as far as the line of demarca tion between the exposed and covered parts of the articular cartilag (Plate III). This procedure may give relie for a short time when the symptoms ar strictly limited to the bunion, but unfor tunately it is usually followed by an in crease in the deformity and a radica operation becomes necessary at a late date.

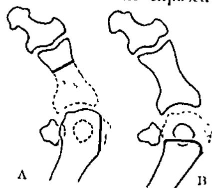


FIG. 201 Operations for Hallux valgus based on (A) Keller's procedure, (B) Mayo's procedure

There are two types of radical operatio each with its advocates who employ it a a routine procedure (Fig. 201). In *Keller's operation* the proximal two-thirds of th proximal phalanx of the big toe is excise together with the bunion and inner part o the metatarsal head. In the modified *Mayo's operation*, the proxima phalanx is not disturbed but the distal part of the metatarsal head is removed. The amount removed varies slightly with the individual, but is usually about five-sixths of the head; if too much is taken away, the sesamoids are left without support and the result is a painful foot of the most intractable type.

A careful technique with a minimum of unnecessary trauma is essential It is particularly important to dissect the flexor and extensor tendons from the bone in such a way that they are not exposed or they will later adhere to it. Damage to the sesamoid bones must be avoided, especially if they are already osteoarthritic, or they also will become adherent. If the bunion is infected, it should first be drained or dissected out and the major opera tion postponed for some weeks.

After-treatment needs as much care as the operation itself. The author prefers Keller's operation and afterwards bandages the t so as to hold

slightly downwards and outwards; if it is at once pulled inwards to rrect the deformity, the skin is folded between the bones and may ugh. Active and passive movements to the extent permitted by the essings are commenced on the second day. The stitches are removed and ight-bearing begun on the tenth day. Soft slippers are not permitted id the joint is given the protection of strong leather shoes for a fortnight women usually need men's shoes.

The patient must make the effort to walk correctly from the start and take the weight on the ball of the big toe even if it hurts—no hobbling lowed. Intrinsic re-education as described for metatarsalgia is absolutely sential when there is anterior metatarsal pain. Constant supervision is cessary for a couple of months to ensure that movement of the toe is aintained and the intrinsic muscles are properly used. Most patients are ble to return home and walk without too much discomfort a few days ter they get up, and then there should be steady improvement for two or iree months when complete freedom from pain may be expected.

Secondary Deformities. Correction can usually be carried out at ie same time as the big toe. Hammer toe and mallet toe are straightened y the usual methods (q.v.). Dorsal dislocation of the second toe cannot be duced but excision of the entire proximal phalanx gives a satisfactory sult. The second toe should never be amputated, or the big toe, left ithout support, deviates further and causes the third toe to become eformed.

Valgus deformity at the interphalangeal joint of the big toe occurring lone or at the same time as hallux valgus occasionally requires correction. his is done by arthrodesis of the interphalangeal joint; bony union is low after simple excision of the joint and a "step" operation or a bone raft is desirable.

Children. Advice as to treatment for early deformity in children is ften sought but it is not easy to give because, unless the metatarsus varus an be corrected, there is little hope of preventing deviation of the halanges. Remedial exercises appear to have little effect; some children ave even learnt to abduct the big toe actively and practised it constantly or years, but without benefit. Special shoes, and a variety of contraptions lesigned to hold the toe straight, are just as ineffective.

Operation to correct the metatarsus varus may be recommended when the deformity has started very young and increased steadily so that t is obviously going to be severe later in life. Under the age of about 12 in girls and 14 in boys, the best procedure is probably that recommended by *V. H. Ellis*; growth is arrested at the outer side of the epiphysis at the base of the first metatarsal by bridging the epiphysial disc with staples (p. 34). For older children, *Joplin's operation* is satisfactory. The metatarsus varus is corrected temporarily by passing the tendon of the long extensor of the little toe across the sole of the foot, through a hole drilled in the first metatarsal head and pulling it tight; permanent control is given by detaching the adductor muscle of the big toe from its insertion into the proximal phalanx and passing it through the same hole.

HALLUX RIGIDUS

The normal range of dorsiflexion at the metatarso-phalangeal jo of the big toe is about 90°; when walking ordinarily the toe dorsifle: between 20° and 30° during the "take off" phase, and rather more wl walking fast or running, or when wearing high-heeled shoes. Wl dorsiflexion is limited the condition is known as hallux rigidus; there two varieties, acute and chronic.

Acute Hallux Rigidus

This type is rather uncommon and is seen chiefly in adolescents w long narrow feet, and only rarely in adults. Not infrequently it is bilate: Trauma, such as stubbing the toe or wearing shoes that are too short probably an ætiological factor.



FIG 202 Method of applying extension in acute hallux rigidus

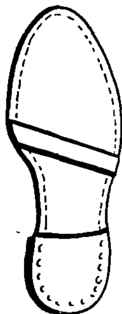


FIG 203 Outside metatarsal bar

The pathological condition varies; sometimes the articular cartil is bruised, sometimes the synovial membrane and periarticular tissues inflamed, and sometimes there is tenosynovitis of the extensor hallu longus. The patient complains of severe pain on using the foot, walk is difficult, and even the pressure of the bedclothes hurts. Examinat shows that the toe is held rigid by muscle spasm, there is tenderness o the metatarso-phalangeal joint, and sometimes over the tendon of long extensor.

Treatment. The condition must be taken seriously because if i neglected, the articular cartilage is destroyed and the joint will alm certainly become permanently stiff. The longer treatment is delayed, smaller is the chance of success.

The chief indications are to rest the joint and to relieve the joint s

faces from the pressure caused by muscle spasm. A plaster cast is applied from below the knee to the tip of the toes and a wire hook incorporated so that it extends about 3 inches beyond the big toe; elastic extension is attached to the toe by adhesive plaster (Fig. 202). Extension is maintained for four to six weeks during which time spasm usually disappears. If there is residual limitation of movement, the joint should be protected for a time by a metatarsal bar fixed to the outside of the shoe (Fig. 203).

Chronic Hallux Rigidus

This is the common type which occurs chiefly in adults, in men more frequently than women, and particularly in footballers and in individuals with an extra long big toe. It is frequently bilateral. Trauma may be an



FIG 204 Hallux rigidus

ætiological factor; sometimes it is possible to incriminate a single blow, but more often there are repeated minor injuries. Chronic symptoms also follow neglected acute hallux rigidus.

The pathological changes are those of osteoarthritis (Fig. 204). The articular cartilage on the metatarsal head is eroded and osteophytes form around it, chiefly on the dorsal surface but also on the inner and outer aspects. Similar changes often occur at the base of the proximal phalanx and in the sesamoid bones. A bursa may form over a projecting osteophyte and cause much pain. Compensatory movement often develops at the inter-phalangeal joint which acquires a range of dorsiflexion of 60° to 90°.

Symptoms. Pain does not vary exactly with the amount of stiffness. Some people have quite stiff big toes all their lives without any symptoms, but others get pain whilst there is still considerable movement. The patient illustrated in Fig. 205 had a rigid toe but no symptoms except from the pressure of the bursa on the shoe.

The toe usually stiffens gradually and the patient learns to dodge the lack of movement when walking partly by rolling on to the outer border of the foot, and partly by dorsiflexion at the interphalangeal joint. The final position of the toe may be such that it is flat on the ground when standing, but sometimes it is plantar flexed and the metatarso-phalangeal joint is raised from the ground. There is seldom an associated valgus deformity.



FIG. 205 Hallux rigidus with a large exostosis on the dorsum of the first metatarsal head

The onset of pain is often precipitated by a minor injury, but once established it persists indefinitely. The actual cause of the pain varies; it may be due to movement of the osteoarthritic joint, to weight-bearing on osteoarthritic sesamoid bones, pressure on an exostosis or bursa, strain on the interphalangeal joint, or to callous on the skin under the joint. Anterior metatarsal pain caused by walking on the outer border of the foot is often the outstanding symptom.

Treatment. Some relief may be given by a metatarsal bar fastened to the sole of the shoe to act as a rocker and replace the movement of the joint. The bar should be three-quarters of an inch broad and extend obliquely across the whole width of the shoe immediately behind the tread (Fig. 203), or it may be built in between the welt and the sole where it is less unsightly but less effective. A pad of zinc oxide felt plaster can be used to protect the sesamoids from pressure when they are tender.

Operation is the only method of relieving the symptoms in the majority of patients and an arthroplasty of the metatarso-phalangeal joint is performed by one of the methods described for hallux valgus (p. 274). The results on the whole are good but normal function cannot always be restored because of the difficulty in learning control of movements that have been in abeyance for a long time.

When the toe has been quite ri[illegible] many year[illegible] operation is

required chiefly to relieve symptoms in connection with an exostosis, arthrodesis is often a better procedure. The joint is excised and bridged with a graft cut from the metatarsal; a walking plaster is worn for about ten weeks. The results are surprisingly good provided the toe is fixed at the exact angle requisite for the height of heel customarily worn.

ONYCHOGRYPHOSIS

Hypertrophic growth of a toenail, usually of the big toe, appears to be the result of intermittent pressure continued over a long period (Fig. 206). The nail is a specialized development of the stratum corneum of the epidermis; it is firmly adherent to the stratum mucosum, here known as

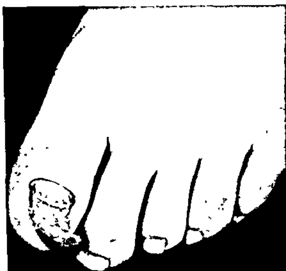


Fig 206 Onychogryphosis

he matrix, or nail bed. Growth in length takes place by proliferation of the ells of the *stratum mucosum at the root of the nail, and growth in thick*ess by proliferation of the stratum mucosum underlying the lunula: Excessive productiveness in the latter region causes the nail to become hick, and failure to "slide" forwards properly during growth causes it to ile up and form a structure which is said to resemble a ram's horn.

Treatment. The nail is very hard and almost impossible to cut with cissors, but it is easily reduced by an electric burr and can be kept under control by regular attention from a chiropodist. Avulsion of the nail, although sometimes necessary for the treatment of infection, is nvariably followed by recurrence.

Permanent relief can only be given by complete ablation of the nail bed. The nail is removed and a flap of skin on the dorsum of the distal phalanx is raised. All tissues down to bone are excised between a point just distal to the interphalangeal joint and the centre of the nail. Particular attention is given to the lateral angles at the base of the nail bed because most troublesome spurs of nail continue to grow if any matrix is left. The distal portion of the phalanx is excised to shorten the toe and provide enough skin to cover the raw area.

SUBUNGUAL EXOSTOSIS

A small exostosis sometimes grows on the dorsum of the distal part of the terminal phalanx, most frequently of the big toe (Fig. 207). As it gets larger it lifts up the nail matrix and compresses it against the nail; ultimately the matrix degenerates and forms a horny scab over the exostosis.



Fig 207 Subungual exostosis.

The condition is very painful and can only be relieved by operation. If dealt with early, the exostosis can be approached through a lateral incision and the matrix dissected up without being perforated; healing is then by first intention and convalescence is short. If, however, the matrix has ulcerated, a raw area is left after removal of the exostosis and it has to heal by granulation.

HAMMER TOE

A hammer toe (Fig. 208) has a right angle flexion deformity at the proximal interphalangeal joint; the soft tissues underneath are contracted and prevent the toe being straightened. The distal interphalangeal joint may be flexed, straight or hyperextended. The metatarso-phalangeal joint is hyperextended and the proximal phalanx rests on the dorsum of the metatarsal head pointing obliquely upwards; the extensor tendon is contracted and stands out over the joint.

The deformity may be present in only one toe, most frequently the second, and less often the third or fourth. It may be symmetrically bilateral, and sometimes several toes are affected. The cause is uncertain, but in a few instances there is a familial history; in some patients the toe is drawn up as if to avoid pressure from a deformity of the next toe, usually a valgus big toe, and sometimes, when the toe is unduly long, ill-fitting shoes or hose may be responsible.

Many hammer toes are symptomless, but some are most painful. Pain may be due to a corn on the dorsum of the contracted joint or on the extreme tip of the toe, or it may be due to metatarsalgia caused by the toe forcing the metatarsal head downwards and making it prominent in the sole of the foot.

Treatment. Babies. The toe can be held straight by strapping it to its neighbours but this has to be continued for many months, possibly years, to obtain a permanent result. A narrow strip of adhesive plaster is wound round the base of the toes startin der the big toe, passing above



FIG 208 Hammer toe with a painful corn on the dorsum of the proximal interphalangeal joint

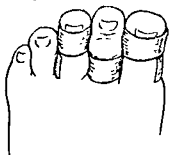


FIG 209 Method of strapping a hammer toe during infancy



FIG 210 "Spike" operation for hammer toe

he second toe and under the third ; a second strip is placed under the tip f the second toe and passed above both the others (Fig. 209). A similar method of strapping may be used for minor valgus or varus deformities at the interphalangeal joints of any of the outer four toes.

ADULTS. Removal of the painful corn is nearly always followed by recurrence unless the toe is protected from pressure more or less permanently by padding. This is a troublesome business and most patients are glad enough to have the toe straightened by operation. Amputation of the second toe must never be performed because it removes the support from the big toe which then deviates outwards and presses on the third toe, then this toe curls up and requires removal also, and finally the fourth toe causes trouble.

The usual operative procedure is arthrodesis of the proximal interphalangeal joint of the affected toe. This can be done by means of a simple, transverse excision of the joint, but union is very slow. The "spike" operation is more satisfactory ; the articular cartilage is removed from the base of the proximal phalanx and a tapering hole bored in it, then the distal end of the proximal phalanx is pointed and impacted in the hole (Fig. 210). The extensor tendon may need tenotomy. After operation the toe is splinted by wrapping it with ribbon gauze soaked in mastisol. The stitches are removed on the tenth day and walking commenced ; the splint is reapplied for a further fortnight by which time union should be firm and the toe painless.

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Treatment. Babies. The toe can be held straight by strapping i its neighbours but this has to be continued for many months, poss years, to obtain a permanent result. A narrow strip of adhesive plast wound round the base of the toes starting under the big toe, passing al



Fig. 211 Mallet deformity of the third toe There is a painful corn on the tip close to the nail



Fig 212 Dorsal displacement of the fifth toe.



Fig 213 Dorsal exostoses at the first tarso-metatarsal joints.

MALLET TOE

A mallet toe is one with a flexion deformity at the distal interphalangeal joint and it may occur at any of the outer four toes (Fig. 211). The condition may be painless, or there may be pain from a corn on the dorsum of the joint, or on the tip of the toe close to the nail. The latter is particularly painful and resistant to conservative treatment.

Treatment. In children the deformity may be prevented from becoming fixed by strapping in a similar way to hammer toe. Adults can be kept comfortable as long as they are prepared to visit the chiropodist regularly to have the corn attended to and the toe padded.

Operation is usually preferred. A "spike" operation as for hammer toe is impracticable because of the small size of the distal phalanx. Simple excision of the joint has therefore to be performed, but union is usually by fibrous tissue and it may be some time before there is complete freedom from pain. A more rapid result is obtained by amputation of the terminal phalanx.

DORSAL DISPLACEMENT OF LITTLE TOE

This is a congenital deformity in which the little toe is displaced dorsally and twisted so that it lies across the base of the fourth toe (Fig. 212); with an extreme deformity, the toe is angulated 90° and lies on the neck of the fourth metatarsal. The defect is rather unsightly, and makes it difficult to find a comfortably fitting shoe, but apart from this it does not cause much trouble in children. In adults, however, there is often pain due to pressure and friction, and a painful soft corn that will not yield to conservativ [illegible]

Replacement o [illegible] by a return of functi [illegible] functionless although the cosmetic result is good. Reposition is, therefore, best performed during childhood, preferably about eight to ten years of age. The extensor tendon is divided and the dorsal capsule of the metatarsophalangeal joint incised; the toe then falls into position but the skin is stretched so tightly that it requires "lengthening" by the V-Y or a similar method.

DORSAL EXOSTOSIS

A rather troublesome prominence often develops on the dorsum of the foot in connection with the first tarso-metatarsal joint (Fig. 213). It is not a true exostosis but an enlargement of the first metatarsal and first cuneiform bones on each side of the joint. Sometimes an adventitious bursa forms over it.

The swelling is just where the strap of a certain type of shoe crosses the foot. Symptoms may be caused by friction or pressure, and they are usually relieved by a change of footwear. If necessary, the prominence can be removed surgically; a saucer-shaped depression should be cut in the bone or some swelling will remain after operation.

PLANTAR WARTS

Plantar warts (*verruca pedis*) are very common, especially in young people, and exceedingly painful. They may occur anywhere on the sole of the foot but usually under the heel, the ball, or the terminal phalanx of the big toe. They vary in size from minute seeds up to an inch in diameter.

There is doubt about the aetiology but the evidence is in favour of an infective origin, the causative organism possibly being a filter-passing virus. Local dissemination takes place around the primary wart and there may be a whole crop close together. Warts are transferred from person to person by direct contact, and through intermediate agents such as socks and bath mats; epidemics in schools are therefore common.



Fig 214 A plantar wart on the heel

A wart has a typical papillomatous structure, but instead of projecting beyond the skin it is buried under the horny layer with only the tips of the papillæ sticking through. It appears as a circular area with a dark, punctate surface and is excruciatingly tender to touch. It may be necessary to shave off the superficial layer before the typical appearance can be recognized.

Treatment. Small warts can usually be destroyed by a caustic, almost any caustic will do. Glacial acetic acid is easy to handle and may be re-applied every two or three days; the horny layer should be pared down before application. The actual cautery, carbon dioxide snow and electrolysis are also used with success.

Larger warts are difficult to destroy completely by local applications but they are readily removed with a sharp curette. The margins extend some distance under the skin and it is essential that no fragments are left behind; it is advisable to use a tourniquet to prevent the view being obscured by blood. The resulting hole is plugged with cotton wool; it is sometimes of alarming size but it fills up rapidly and heals without leaving a scar. It is seldom necessary to keep the patient in bed.

CORNS AND CALLOUS

Corns and callous are both produced by intermittent pressure and friction over an area of solid resistance. There is no satisfactory explanation as to why some corns develop in such a way as to be painful, and some do not. Painful corns are important not only because of the attendant pain, but also because they cause mis-use of the foot which leads to other troubles like metatarsalgia.

Corns may be hard or soft and there is no essential difference between them.

Hard Corns. These form over bony prominences, particularly at the outer side of the little toe, over the dorsum of an interphalangeal joint, and under the tip of the toe close to the nail. They are composed of an area of hyperkeratosis with a more deeply penetrating central nucleus which also is keratinous, but partly degenerated. The pain is due to pressure on the nerve endings in the papillary layer of the dermis. There is often a small sac containing fluid underneath the nucleus, and periodic exacerbations of pain may be due to recurrent inflammation of the sac.

Soft Corns. They favour moist places where skin is in contact with skin, the commonest site being between the fourth and fifth toes. They have a soft, whitish appearance with a depressed central area, but in structure are essentially the same as hard corns.

Callous. Most people have some callous around the heel and under the ball of the foot, but the amount varies with the individual and it is difficult to say when it becomes pathological. Callous normally is painless; it becomes painful because of changes in the deeper layers resembling those in a corn. The severity of pain depends on these changes and not on the thickness of the callous.

Treatment. A corn can almost always be cured by local treatment but it will certainly recur unless the cause is removed. The cause may be found in badly-fitting shoes, deformities of the toes or foot, or faulty use of the foot.

Local treatment of a corn is described by chiropodists as being "non-operative" and "operative." Non-operative methods rely on softening the keratinized skin by repeated applications of a preparation containing salicylic acid, or some similar agent; the horny layer eventually separates and often carries the central nucleus with it. Operative treatment is most skilfully performed by the chiropodist; the hardened layer is either dissected away from the healthy skin or pared down until level with it, and the nucleus is removed intact. Surgical excision of a corn is very seldom needed.

Painful callous can be got rid of by the same methods as corns, but it is very difficult to prevent it recurring and relief usually lasts only too short a time. The worst growths cannot be controlled by chiropody and it may be necessary to excise the skin of the affected area and replace it with a graft. Radiotherapy is sometimes advised but it must be carried out with extreme caution because of the risk of burning the sole of the foot.

nail bed as for onychogryphosis (p. 279). Operations at which only part of the nail bed and a redundant fold of skin are removed sometimes leave a painful scar but they are useful when the final appearance is of greater importance than usual (*Fig. 216*).

RINGWORM

Mycelial infection between the toes is exceedingly common even in temperate climates, and in hot climates it is almost universal. The infection starts as a rule in the cleft between the fourth and fifth toes and rapidly spreads to the others. If kept dry, the skin cracks and desquamates leaving sore patches, but when moist, it becomes white and sodden. The condition is not really troublesome unless there is secondary infection and then the usual signs of acute inflammation are present, sometimes including cellulitis of the toes and dorsum of the foot. The diagnosis depends on demonstration of the fungus, but intertrigo of the toes from other causes is uncommon and microscopic examination is unnecessary as a routine.

Treatment. The infection is not difficult to control, or even to cure. A satisfactory application in the ordinary case without secondary infection, is: ℞ Ac. Benzoici gr. XXV
Ac. Salicylici gr. XV
Acetone ʒ ii
Sp. Vini Indust. ad ℥ i

The lotion should be applied twice daily after washing between and beneath all toes, not only to affected areas. When there is gross secondary infection, the sodden skin should be carefully removed and the toes soaked in a weak solution of potassium permanganate.

The chief problem is to prevent re-infection and this is most difficult in the ordinary conditions of community life. Meticulous attention to the hygiene of the feet is the most important practical measure. The socks should be changed daily and the feet washed and properly dried at least once a day, preferably twice, and the lotion applied afterwards. Some patients find it necessary to continue using the lotion indefinitely.

HYPERIDROSIS

Excessive sweating of the feet may be a local phenomenon or a symptom of a generalized condition. Sweating is under the control of the sympathetic nervous system and no satisfactory explanation has been offered as to why excessive sweating often occurs in the feet alone. When severe, the sweat pours off the feet, the skin becomes sodden, the socks need changing many times daily, and both socks and shoes rot quickly. In some cases the sweat decomposes and has an offensive smell.

Treatment. Minor degrees can usually be kept in control by careful attention to the toilet. The feet should be washed frequently in a mild deodorant and dried with spirit, and the feet, socks and shoes dusted liberally with a powder composed of equal quantities of talcum and boracic acid. Occasionally lumbar sympathectomy, which prevents all sweating in the limbs, is justified.

INGROWING TOE NAIL

(*Synonym*) Onychocryptosis

The principal cause of this painful condition is pressure by tight shoes or hose, or an overlapping toe, but a simple explanation cannot always be found. The deformity itself causes little discomfort; the symptoms are due to infection and therefore they often occur when the feet are ill-kept.

The nail is thickened, the curve is increased, the edges are pressed down into the soft lateral nail grooves and the surrounding skin is hypertrophied. If the free edge of the nail has not been cut across its whole width, a spike may remain hidden in the nail groove and penetrate the soft tissues as it grows. Infection is introduced by the spike, or by an ulcer that forms on the fold of skin where it is pressed against the nail, and pus spreads round the edge of the nail and penetrates between the nail and matrix. The usual signs of inflammation are present.

Treatment. Conservative. The first step is to get rid of the infection. The toilet of the nail is attended to, all rough edges are smoothed off,



Fig 215

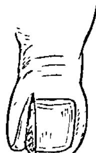


Fig. 216.

and if there is pus beneath it, part of the nail is cut away. Pledgelets of cotton wool soaked in a mild antiseptic are introduced under the free edge of the nail and into the lateral grooves.

When the nail is thick and sharply curved, the direction of spring seems to be reversed causing it to curl down and press into the flesh. The traditional remedies of cutting a V into the free edge, or of shaving the centre of the dorsum thin, are based on this observation and are intended to "break the back" of the nail so that it no longer curls downwards. A groove scratched the entire length of the nail about a quarter of an inch from the margin has the same effect; this is done with the point of a knife or the corner of a safety-razor blade, the groove being deepened until the horny layer is almost perforated, that is when pain is first felt (Fig. 215). The patient is instructed to keep the groove going as the nail grows, and also to watch for a spike at the corner of the nail; symptoms may not recur if the toe is kept scrupulously clean

Operation is called for when conservative measures have failed, and when the nail is very thick or otherwise deformed. Avulsion of the nail is almost always followed by recurrence when the new nail grows and the most satisfactory procedure is to excise the nail together with the whole

dorsalis, syringomyelia and peripheral neuritis. The vascular element is most conspicuous when the sympathetic nervous system is disordered.

Treatment. The systemic disease should first be treated, and when this is tabes, antisyphilitic measures will probably improve the local condition. Rest is essential in the presence of active pyogenic infection. Drainage is provided by removing the callous around the sinus, taking care not to damage the healthy skin, and then enlarging the opening. The sinus is irrigated with a mild antiseptic and lightly packed to keep it open. The cavity closes from the bottom very slowly and, although it seldom heals completely, it should be possible to keep it in control for an indefinite period. Radical surgery is not advisable, but if the dorsum of the foot is swollen, it may be necessary to incise it and remove necrotic bone; the incision should be dorsal.

GOUT

The incidence of gout is very much smaller than it was at the time it was so graphically described by Sydenham, but it is by no means uncommon and the diagnosis is often missed; it is as likely to be encountered in a teetotaller or moderate drinker as in a heavy drinker. A great majority of sufferers are men, but typical symptoms do occur in women who account for about ten per cent of all cases. The big toe is the usual joint to be attacked but other joints, especially the small joints of the hand, may be affected. The older writers attributed the particular susceptibility of the big toe to its liability to injury and to the sluggish circulation around the joint. Symptoms are due to the deposit of crystals of sodium biurate in the articular and periarticular tissues. The bone is involved early and reacts by osteoclastic resorption forming small cysts, and during the acute phase crystals appear on the surface of the articular cartilage.

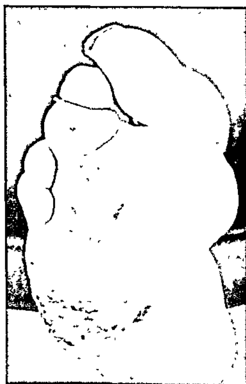
An acute attack of gout may be heralded by a variety of premonitory symptoms such as a minor disturbance of the gastro-intestinal tract or the urinary system, but as a rule it comes on suddenly, perhaps during the night, when the victim is awakened by pain. The pain increases rapidly in intensity and after 48 hours it can be so extreme that the slightest jar is excruciating. There is œdema around the joint and the skin is tense, shiny and of a characteristic dull red colour. The joint is very tender and all movement most painful. The temperature may be raised to as high as 102°. During the day there is often partial abatement of pain and approaching relief may be heralded by perspiration and mild rigors. As the attack subsides, the œdema and discolouration become less but the skin begins to itch and later desquamates.

Attacks have an average duration of one to two weeks although sometimes they last longer; they almost always recur after an interval varying from a few months to a year or two, but isolated attacks have been recorded. The attacks tend to become successively more severe and the intervals between them shorter.

The diagnosis is obvious when the disease is well established, but it may be difficult during the early stages, and in women. It should be con-

PERFORATING ULCER

All the ordinary forms of ulcer occur on the foot and follow the usual clinical course, but perhaps they are more indolent than elsewhere. Perforating ulcers are not peculiar to the foot although they are rare elsewhere. They are usually found under the first metatarsal head, less often under the fourth and fifth metatarsal heads, and occasionally at any other weight-bearing site including the interphalangeal joint of the big toe.



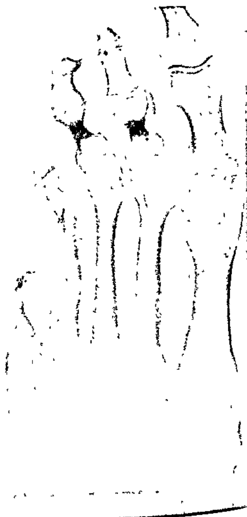


FIG 217 Perforating ulcer in a patient with tabes dorsalis

"Ulcer" is a misnomer because ulceration is the least obvious feature; there is a sinus with a small opening concealed in a mass of heaped-up callous (Fig. 217), and the sinus leads to a cavity deep in the foot which may ramify between the metatarsals and extend to the subcutaneous tissues at the dorsum. There may be a low-grade osteomyelitis of the metatarsal bones. The absence of pain is characteristic and most sinuses can be probed, and sometimes even curetted, without causing pain.

Perforating ulcers are found in association with diseases in which there is interference with the sensory nerves and the blood supply of the foot. The commoner of these are diab peripheral nerve injuries, tabes

SWELLING OF THE FOOT AND ANKLE

Swelling of the foot and ankle may be caused by (1) œdema, (2) hypertrophy of the subcutaneous fat, and (3) tumours and diseases of the deeper structures. Systemic disease must always be excluded before œdema is attributed to a local cause.

Œdema. Injury to the foot, whether a fracture, an acute sprain or chronic foot strain, is almost always accompanied by œdema. The swelling increases during the day and its lower limit is sharply defined by the shape of the shoe; it diminishes or disappears at night when the limb is elevated. It is very persistent because there is no large bulk of muscle to assist in removing it mechanically. Continued œdema is an indication that an injury has not completely resolved; this is particularly noticeable with an acute sprain that has become chronic, and in a foot that has become stiff after immobilization in plaster for, say, fracture of the tibia. The swelling does not go completely until the full range of painless movements has been restored.

Œdema of the foot and ankle frequently follows injury of higher parts of the limb because the excess of tissue fluid gravitates downwards. It may also be caused by lymphatic or venous obstruction at the groin and pelvis. Occasionally œdema of lymphatic type with cellular hypertrophy in the subcutaneous tissues occurs without any discoverable cause and then an operation of the Kondoleon type may give partial relief.

There is a type of œdema occurring chiefly in young women of eighteen to twenty-five years of age which is not associated with trauma or visceral disease. It may be unilateral or bilateral and it is painless, complaint being made only of the appearance. Osmond has shown that this type may be due to a disorder of water metabolism and is associated with a low alkali reserve. It can often be relieved by the administration of massive doses of alkali. Sodium citrate is given commencing with 600 grains daily divided into nine or ten two-hourly doses, each taken in a glass of water. The daily quantity is increased every fourth day by 200 grains up to a maximum, which is determined by the onset of gastro-intestinal symptoms, of about 1,200 grains, and this is continued for a week.

Hypertrophy of the Subcutaneous Fat. The subcutaneous fat sometimes hypertrophies to such an extent that it hangs in folds round the ankles. This occurs chiefly in those who are already overweight because of some metabolic disturbance. Excision may be attempted for cosmetic reasons but it is not very satisfactory unless the primary disorder can be relieved.

Diseases and Tumours of every sort affecting bones, joints or tendons are liable to cause swelling. Difficulty has often been occasioned by a diffuse synovioma which frequently is wrongly diagnosed before operation, much to the surprise of the surgeon who thinks he is only going to encounter a lipoma. Complete excision of this tumour is essential to prevent local recurrence and a very extensive dissection following the tendons into the sole of the foot may be necessary (p. 366).

sidered whenever there are recurring attacks of arthritis in a middle-aged person whether there is a family history of gout, or not. X-rays show soft tissue thickening at an early stage. When the bone is involved, "punched-out" areas appear first in the bone adjacent to the joint, and later on the articular surface (Fig. 218).



FIG 218 Gout showing deposits in the head of the first metatarsal, the proximal phalanx of the big toe and the subcutaneous tissues at the outer border of the foot

In chronic gout, tophi composed of thick, creamy fluid containi sodium biurate crystals form in the subcutaneous tissues around the affe ted joints and in the bone adjacent to the articular cartilage. Occasional subcutaneous bursæ, particularly at the elbow, are involved. Repeat attacks in the big toe lead to disorganisation of the joint accompanied by symptoms resembling severe hallux rigidus, but it is unwise to perform

surgically with advantage. A single dose of butazolidin, if given promptly, will often abort an acute attack.

PAIN BEHIND THE HEEL

Pain behind the heel may originate in any of the structures composing the heel, viz., the skin, the subcutaneous tissues, the tendo-Achillis, the retro-tendinous bursa, the calcaneus and its apophysis (*Fig. 220*).

Skin and Subcutaneous Tissues

Inflammation behind the heels is common in girls and young women, but it is less often seen in boys. The skin is red, swollen and tender as if with a chilblain, the subcutaneous tissues are thickened and a bursa may form superficial to the insertion of the tendo-Achillis. It is evidently associated with a deficient local circulation because it occurs chiefly in temperate climates and is worse in cold weather.

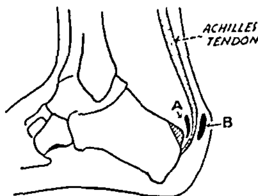


Fig 220 A Retro-tendinous bursa B Subcutaneous bursa The shaded area of the calcaneus, when enlarged, may require removal

Often the cause of the trouble cannot be found, but sometimes it appears to be due to friction between the heel and the top of the back of the shoe; the latter is often made to curve inwards more sharply than it need in an attempt to get a snug fit. Sometimes the cause is enlargement of the postero-superior angle of the calcaneus which projects backwards making a lump under the skin; and sometimes the lateral, vertical borders of the calcaneus are enlarged but then the pain and swelling are situated lower and more laterally.

Treatment. The condition is seldom seen after about twenty-five years of age, and therefore there must be a strong tendency to spontaneous recovery. Mild pain can be relieved by attention to the fitting of the shoes, and by wearing a "heel protector" obtainable from most shoe-shops. When there is enlargement of the posterior angle of the calcaneus, high heels tilt the bone forwards and help to relieve pressure, but if there is no enlargement, low heels are more suitable.

Operation may be necessary to remove a subcutaneous bursa or an enlargement of the calcaneus; the postero-superior angle of the latter is bevelled off with a chisel down to the level of the insertion of the tendo-Achillis (Fig. 220). A lateral incision must be used to prevent friction on the scar.

PAIN UNDER THE HEEL

This common complaint of middle-aged and elderly people is nearly always due to inflammation of the plantar fascia and the short muscles at their attachment to the calcaneus (*plantar fasciitis*). It may be traumatic or infective in origin but more often no explanation can be found. Pain and tenderness are accurately localized to a small area beneath the heel, usually on the inner side immediately in front of the pad.

The relationship of spurs of the calcaneus to pain under the heel is often misunderstood. Spurs are produced by ossification in the plantar fascia and the tendinous origin of the muscles as the result of inflammation or repeated minor trauma (Fig. 219). They are often seen in radiographs taken for other reasons, and are often present in both feet when there is



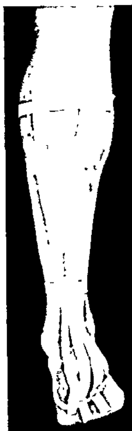
FIG 219 A calcaneal spur, although a common radiological finding, is seldom a cause of pain

pain in only one. Spurs do not cause pain unless they are very large; the pain in plantar fasciitis is identical whether a spur is present or not, and in both cases the pain is due to inflammation.

Treatment. The condition is often resistant to treatment and may take months to clear up. Pain can be relieved temporarily by an injection of proctocain, and if repeated several times the result is sometimes permanent. Comfort is given by a sorbo pad cut to fit the heel of the shoe and hollowed out exactly opposite the tender area. Diathermy may assist resolution, but usually it has to be continued for a long time.

Surgical excision of spurs is disappointing because spurs do not cause pain unless they are large enough to be palpable in the sole. Excision of the plantar fascia and muscles for a distance of about half an inch from their attachment to the calcaneus, together with a spur if one happens to be present, is sometimes successful and may be tried when all other treatment has failed.





Above Fig. 221 Apophysitis of the calcaneus

Right Fig. 222 Strapping the foot in equinus

Operation is usually preferable. If the injury is recent, end to end suture may be possible, but the tendon is often in a friable condition and it is difficult to obtain a firm hold for the sutures. With old injuries and some recent ones it is necessary to fashion a flap from the proximal end of the tendon, and if possible from the distal end also, and suture them together (the tendon of the plantaris muscle, if present, makes a good living suture). A walking plaster is applied with the foot at right angles to the leg and worn for six weeks.

Partial Rupture. A number of the fibres of the tendon are torn; no gap is palpable, but after a short time a lump forms, as with complete rupture. Continuity of the tendon can be demonstrated radiologically. The foot should be strapped in equinus for several weeks and there is complete restoration of function within a few months.

"PULLED CALF MUSCLE"

This requires separate mention because sudden pain in the calf whilst engaged in sport, and on similar occasions, is commonly ascribed to rupture of the tendon of the plantaris muscle. The plantaris tendon is long and slender, and knowing that the powerful tendo-Achillis can rupture, it is tempting to assume that the plantaris may behave in the same way. As far as I am aware, however, a ruptured plantaris has never been observed at operation. Sudden pain in the calf is due to rupture of a few fibres of the triceps suræ, an injury which is identical with "pulled" muscle occurring in the thigh and requiring similar treatment (p. 217).

Tenosynovitis

Tenosynovitis of the tendo-Achillis sheath occurs as the result of "over-use" in athletes, ballet dancers, etc., and is recognized by palpable creaking on active movement. It responds well to rest. The foot is strapped in extreme plantar flexion ; three strips of half inch adhesive plaster are fixed along the whole length of the sole, round the back of the heel, up the calf as far as the knee, and secured with a few circular bands (Fig. 222). It is then possible to walk wearing a shoe with a raised heel, but patients should be warned not to stand, even for a moment, without shoes. Diathermy is a useful adjuvant.

The bursa between the tendo-Achillis and the calcaneus, and also the fibro-fatty tissues between the tendo-Achillis and the tibia, occasionally become inflamed. The response to rest is usually good but sometimes excision is necessary.

Apophysitis of the Calcaneus
(*Synonym*) Haglund's Disease

This condition occurs in children of eight to fourteen years of age and is probably a form of osteochondritis juvenilis (p. 167). The symptoms are pain, swelling and tenderness at the back of the heel. The X-rays show sclerosis and fragmentation of the apophysis and sometimes areas of rarefaction in the adjoining metaphysis (Fig. 221).

The disease runs a benign course and usually recovers in a few months. It is not necessary to keep the child in bed, but games and drill should be avoided. Pressure on the heel, if painful, can be prevented by removing the stiffening from the back of the shoe or cutting a hole in it; thin-soled shoes or plimsols should not be worn.

RUPTURE OF THE TENDO-ACHILLIS

This is an injury of middle-aged men and less often of other people. The classical occasion for it to happen is when father turns out to play in *Parents* v. *Boys* at cricket ; on starting to run he gets a sudden pain behind the ankle as if from a blow, and he falls over. The rupture is usually about one and a half inches above the insertion of the tendon where it is narrowest, and it may be complete or partial.

Complete Rupture. The upper end of the tendon retracts and at first a gap is palpable, but it quickly fills with blood clot and then there is a small firm lump instead of a hollow. The gap in the tendon can be demonstrated radiologically.

CONSERVATIVE TREATMENT consists in raising the heel of the shoe and strapping the foot in equinus (Fig. 222), or applying a plaster cast with the foot in the same position. The position should be maintained for six to eight weeks by which time fibrous tissue will have grown across the gap and united the ends of the tendon. The function is reasonably good but the tendon remains rather longer than before, the gait loses some of its spring, and the power of standing on tiptoe may be permanently lost.

except after severe injuries. When possible the ankle should be bound with elastoplast immediately after injury and before there is any swelling; if some hours have elapsed since the injury, it is helpful to infiltrate the tender area *with novocain* before the elastoplast is applied. The strapping should extend from knee to toes and an additional turn is made around the ankle to give lateral support. The patient is then taught to walk without a limp in order to ensure proper movement of the ankle. *He should lead as normal* a life as possible avoiding only games and competitive sport, and he should continue training if engaged in athletics. The elastoplast requires renewal after a week, or earlier if there has been much swelling, and it can usually



Fig 224 Manipulation of ankle—stretching the middle fasiculi of the external lateral ligament

e discarded after a fortnight. Massage, and possibly further infiltration rith novocain, are desirable if pain persists.

Chronic Sprain. When an acute sprain is inadequately treated a painful scar often forms in the ligament. In a severe case there is pain whenever the ligament is placed under strain, as when walking on rough ground, and there may be recurrent attacks of swelling following minor twists of the ankle.

Treatment is by manipulation under anæsthesia. The anterior fasiculi of the external lateral ligament are placed under tension by forcing the foot into full inversion and plantar flexion, the middle fasiculi are stretched by the method shown in Fig. 224, dorsiflexion is restored as in Fig. 223, and the ankle is distracted as in Fig. 181, p. 252. After manipulation the range of movements should be maintained by massage, passive movements and active exercises.

THE LATERAL LIGAMENTS OF THE ANKLE

The lateral ligaments of the ankle are injured when the foot is forced violently into inversion or eversion, usually inversion. The ankle depends for its lateral stability on the muscles of the calf which have long tendons passing behind the malleoli, but these muscles are primarily concerned with the posture of the foot and control of the ankle is only a secondary function. It often happens, therefore, that the ankle is subjected to violence when the muscles are not prepared to receive it and then the strain is taken by the ligaments. The accident usually occurs whilst walking or running on



FIG. 223 Manipulation of ankle—dorsiflexion.

rough ground when the foot twists and the whole weight of the body comes on to the lateral ligament. The resulting damage may consist of a minor sprain, or a large part of the ligament may be ruptured. In either case there are likely to be troublesome chronic symptoms unless proper treatment is given.

Sprain

A sprain is an injury in which a number of the fibres of a ligament are torn. The usual sites to be affected at the ankle are the lower insertions of the anterior and middle fasiculi of the external lateral ligament, and the upper insertion of the ligament into the external malleolus. Sometimes the anterior capsule of the ankle, usually the outer part, is damaged at its insertion into the tibia, and sometimes the internal lateral ligament is injured at either its upper or lower insertion.

A sprained ankle swells rapidly, there may be œdema of the foot, and also subcutaneous bruising if the injury is severe. There is tenderness at the site of injury, and pain is caused by stretching the ligament. Fracture can usually be excluded by localizing accurately the site of pain and tenderness.

TREATMENT. The sooner treatment is commenced, the more likely is resolution to take place quickly and completely. Rest is contra-indicated

or wearing shoes with pointed heels. The diagnosis, as with the acute lesion, is made radiographically, and an anæsthetic may be necessary before the defect can be demonstrated.

Treatment. The only satisfactory method of treatment is by operation. Several techniques have been described, the best being *Watson-Jones's tenodesis* (Fig. 226). The upper end of the tendon of the peroneus brevis is detached from the muscle belly, passed from behind forwards through a drill hole in the external malleolus, then from above downwards through the neck of the talus, and finally implanted into the external

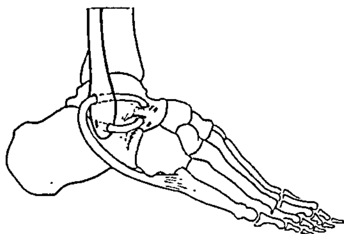


FIG 226 Watson-Jones's tenodesis for recurrent subluxation of the talus.

malleolus. The foot is immobilized in a plaster cast for eight weeks but weight-bearing is permitted after a fortnight. A long period of physiotherapy is necessary after the plaster has been removed, but the end-result is good.

Giving Way of the Ankle

This common complaint troubles women more than men. The ankle gives way as a rule into inversion, and only occasionally into eversion. It usually happens when walking on rough ground although it may occur when on a level surface. The ankle twists very suddenly and often the lateral ligament is sprained producing the usual symptoms of pain and swelling.

Frequently there is a definite cause for the ankle giving way but sometimes no explanation can be found. The known causes are chronic sprain of the external lateral ligament, and recurrent subluxation of the talus. The treatment of both these conditions is described above. When no cause can be found it is tempting to attribute the trouble to high heels, or to wearing shoes with unevenly worn heels which do not rest flat on the ground. But although the ankle gives way less often when wearing good shoes and low heels, it still happens occasionally for no discoverable reason, even when walking on the level. Recurrent dislocation of the peroneal tendons causes comparable symptoms and may be mistaken for "giving way of the ankle."

Rupture of External Lateral Ligament

Complete rupture of the ligament is a not uncommon injury which is caused by the same sort of accident as a sprain. The ligament usually gives way close to its insertion into the fibula and part of the anterior capsule of the ankle is torn at the same time. Sometimes the ligament remains intact and a flake of bone is avulsed from the tip of the fibula.

The injury is serious because it enables the talus to tilt in the mortice of the ankle making the joint most insecure. It should be suspected when



FIG 225 Complete rupture of the external lateral ligament permitting subluxation of the talus

there is a severe sprain followed by considerable swelling and bruising, and the tenderness is localized to the upper insertion of the ligament. Sometimes unnatural mobility of the ankle can be demonstrated on examination, but often clinical diagnosis is uncertain; when there is doubt, an X-ray should be taken whilst the foot is forced into inversion, preferably with the patient anæsthetized (Fig. 225).

TREATMENT. The condition must be treated seriously or the ankle will remain permanently weak. The joint is immobilized in a walking plaster extending from the knee to the toes for a period of eight to ten weeks; the foot should be at right angles to the leg and in a plantigrade position, neither everted nor inverted. A prolonged course of physiotherapy is necessary afterwards to restore the full range of painless movements.

Recurrent Subluxation of the Talus

Untreated rupture of the external lateral ligament leaves an unstable ankle in which the talus can be tilted laterally; the amount of tilt varies with the extent of ligamentous damage up to 70° or 80° (Fig. 225). The ankle continually "gives way," particularly when walki rough ground.

there are often two, and under the inter-phalangeal of the big toe, where there may be one. There is occasionally a single one at the second and fourth metatarso-phalangeal joints, the second and third proximal inter-phalangeal joints and the terminal interphalangeal joint of the third toe (Fig. 227).

Accessory Bones

A number of small bones are found in the foot from time to time in addition to the usual bones of the tarsus. Their importance to the surgeon lies in the ease with which they may be mistaken in radiographs for fractured normal bones. The incidence varies from about 8 per cent in the case of the os trigonum, to rareties like bipartite first cuneiform. They are often, but not always, bilateral.

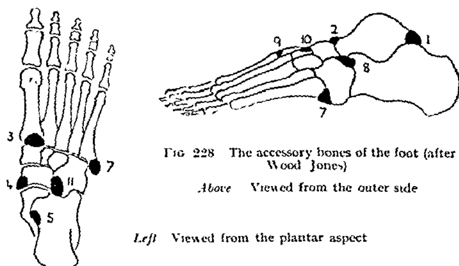


Fig 228 The accessory bones of the foot (after Wood Jones)

Above Viewed from the outer side

Left Viewed from the plantar aspect

Wood Jones emphasizes that accessory bones are not atavistic remnants of a former wider series of tarsal bones, as is often suggested in textbooks of anatomy. He states that only one bone of the primitive vertebrate tarsus is lacking as a separate element in the human foot, the os intermedium. This bone has been absorbed into the talus, but it often fails to fuse with the body of the talus and then it is known as the os trigonum. The remainder of the accessory bones must be considered as congenital anomalies in ossification. The following list is not exhaustive.

1. Os trigonum.
2. Dorsal talo-navicular ossicle.
3. Pars peronea metatarsalis primi.
4. Os tibiale externum (naviculare secundarium).
5. Os sustentaculi.
6. Os cuneiforme primum bipartum.
7. Os Vesalii.
8. Os calcaneus secundarius.
9. Os intermetatarsum.
10. Os intercuneiforme et os paracuneiforme.
11. Cuboides secundarius.

DISLOCATION OF THE PERONEAL TENDONS

The peroneal tendons lie in a groove as they curve round the externa malleolus. They are held in position by the fibres of the lower part of th anterior annular ligament which pass in front of them to be inserte into the calcaneus. Dislocation of the tendons on to the outer surface o the malleolus occurs when the retaining ligament has been ruptured, an also without violence when the groove is shallow and the ligament la It happens when the ankle is dorsiflexed and is readily reduced by planta flexion. The patient may not be aware of what has happened and the histor is not unlike that when the ankle "gives way."

Treatment. When dislocation is due to injury and the correct diagnos is made at once, a pad of felt is placed over the tendons behind and belo the malleolus and the ankle is strapped with elastoplast. The strappin requires renewal at intervals for six to eight weeks by which time th ligament is usually found to be healed.

Recurrent dislocation can only be relieved by operation. There is som times sufficient ligamentous tissue available to reconstruct the tor ligament, and when this can be done it gives a good result. When th groove for the tendons is shallow, *Watson-Jones's operation* is indicated a thick osteo-periosteal flap is raised from the outer surface of the extern malleolus and rotated so that part of it lies in front of the tendons ar forms a tunnel for them.

ACCESSORY AND SESAMOID BONES

Sesamoid Bones

Sesamoid bones occur in tendons at situations where they are und pressure, or where they curve round smooth, bony prominences. Th begin as thickenings in the tendons, later they are converted into car laginous nodules, and finally some, but not all, ossif Ossification usually commences during childhood althou it may take place at any age, even in elderly people.

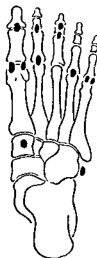


FIG 227 The sesamoid bones (after Wood-Jones).

Sesamoids are of surgical importance because they c be mistaken for loose bodies in joints, and occasionally fo fractured bone. The two sesamoids under the first metat sal head are the only ones in the foot that are constan present, and they have a clearly defined function; the in of these may be in two parts, and occasionally in three four parts (Fig. 193, p. 264).

An ossified sesamoid is found with some frequency the peroneus longus where it curls round the cubo Another occurs, but less often, in the tendon of the tibia posterior deep to the navicular bone. Others may be fou in the tendons of the short flexors of the toes beneath t metatarso-phalangeal joints, and in the long flexors benea the inter-phalangeal joints. The commonest sites under the metatarso-phalangeal joint of the little toe whe

fragment in profile and a number of films at different angles are sometimes necessary (Fig. 230).

Treatment should be conservative in the first place because the symptoms may subside and the joint return to normal. When the pain is persistent, the affected fragment should be removed ; this can be quite a difficult operation.

TUBERCULOSIS

Any of the bones or joints of the foot and ankle may be affected by tuberculosis. The initial focus is more often in bone than in synovial membrane although usually the latter is involved after a short time. The bones most commonly affected are the talus, calcaneus, lower end of tibia, navicular and cuboid in that order of frequency. These bones form the ankle, subtaloid and mid-tarsal joints which therefore are the usual joints to be involved. Of the remaining bones, only the first metatarsal is infected with any frequency (Fig. 231). The maximum incidence is from two to seven years, but no age is immune.

The clinical picture is of slowly progressive swelling, stiffness and pain. Pain is not a marked feature and often tenderness is significantly absent in the early stages. Swelling and stiffness are frequently the first complaints.

Infection of the talus usually commences in the juxta-articular bone adjoining the ankle or talo-navicular joints, and later the corresponding joint is involved. When the ankle is infected there is swelling on each side of the tendo-Achillis and in front of the joint ; the foot is held by spasm in equinus and attempts to force movement are painful. Disease of the other tarsal bones causes local swelling, and spasm of the muscles controlling the neighbouring joints.

The disease follows the usual course of bone and joint tuberculosis but, in the absence of early treatment, spread to neighbouring bones readily takes place and the whole tarsus may be disorganized. Abscesses are necessarily superficial because of the paucity of soft tissue covering and therefore sinuses are common.

The X-rays show the usual appearance of a tuberculous bone (Fig. 232). The first sign is a localized area of trabecular absorption followed, after involvement of a joint, by irregularity in the outline of the joint and narrowing of the joint space. Generalized decalcification is often severe and may involve most of the tarsus and the lower few inches of the tibia.

Treatment

Conservative. Conservative treatment when carried out in proper conditions gives satisfactory results and in children the prognosis is good. But because of the ease with which the foot can be immobilized in plaster whilst the patient goes about on crutches, there is a temptati to prescribe antibiotics and forget the importance of general treatment.

Treatment should be carried out in a country hospital. A full course of chemotherpy is given (p. 429), and the foot a d ankle e immobilized.

OSTEOARTHRITIS

The ankle is affected by osteoarthritis less often than the other weight-bearing joints in spite of the frequency with which it is injured; it seems than the articular cartilage is more resistant to degenerative processes. The usual cause is a crush injury in which the articular surfaces of both the tibia and the talus are damaged.

The symptoms are the usual ones of this complaint—pain, stiffness and deformity. The pain is made worse by walking, particularly on rough ground, and up and down stairs, and it can be really incapacitating. The diagnosis is confirmed radiologically (Fig. 229).

Conservative treatment is seldom of great value although at an early stage manipulation followed by physiotherapy is worth a trial. As a rule arthrodesis is indicated and the functional results are so good that the



Fig 229 Osteoarthritis of the ankle resulting from a crush injury



Fig 230 Osteochondritis dissecans of the talus

patient should not be left in pain for an unnecessary time before it is advised. Arthrodesis is best performed by Charnley's method in which the joint is excised and compression clamps applied (Fig. 170, p. 233). Weight-bearing in a plaster cast is permitted after a month, and the cast can usually be discarded after a further month.

OSTEOCHONDRITIS DISSECANS

This is an uncommon, but not a rare disorder of the ankle. The site usually affected is the border of the summit of the trochlear surface of the talus, and the pathological process is the same as at other joints (p. 219).

The only symptom is pain; examination shows tenderness at the site of the lesion and sometimes periarticular thickening and œdema. The diagnosis is made radiologically but it may be difficult to display the

TALIPES

(*Synonym*) Club-foot

The word talipes is derived from the latin *talus* and *pes*, and originally was applied only to those who "walked on the ankles." Later it was extended to include all deformities of the feet, but the modern tendency is to restrict its use to congenital deformities. Acquired deformities are more usually preceded by the word *pes*, e.g. pes cavus, pes valgus, pes equinus.

Talipes are subdivided into four varieties :—

Talipes Equinus. Plantar flexion of ankle and foot.
Talipes Calcaneus. Dorsiflexion of ankle and foot.
Talipes Varus. Inversion and adduction of the foot.
Talipes Valgus. Eversion and abduction of the foot.

These deformities do not usually occur alone, but in combination. The incidence is given by Whitman as :—

Talipes Equinovarus	77 per cent
Talipes Valgus	7 per cent
Talipes Varus	4 per cent
Talipes Calcaneo-Valgus	4 per cent
Talipes Equinus	2 per cent
Talipes Calcaneus	2 per cent

The condition is bilateral in nearly half the cases, and when unilateral the right foot is affected slightly more often than the left. It is not uncommon for the deformity to be different on the two sides, as might be expected if a mechanical view of the ætiology is accepted.

Ætiology

The cause of congenital talipes has been the subject of speculation for centuries but, of the many theories advanced, only the ancient view of Hippocrates and Galen has remained unshaken. It has recently been elaborated with convincing argument by Denis Browne. According to this theory talipes is of mechanical origin and belongs to a group of "moulding" defects which includes dimples, lumbar spina-bifida, acro-cephalo-syndactyly and other deformities of the hands. All this group is said to be caused by abnormal intra-uterine positions of the fœtus, with sometimes the additional factor of increased mechanical or hydrostatic pressure. Dimples normally form at certain sites like the point of the elbow, and they are also common over the convexity of deformities ; they may be due to pressure between the uterine wall and a bony projection which causes an adherent subcutaneous scar to form. Heredity appears to be a factor in a few instances because the deformity is occasionally familial.

The normal intra-uterine position is such that the feet are dorsiflexed and the soles are in contact with the wall of the uterus—the foot of a new-born baby can be dorsi-flexed until the big toe touches the shin. There are several positions causing abnormal moulding of the feet. The commoner are those in which the outer border or heel of one foot is pressed

The posture of the foot must be arranged with meticulous care or it may become ankylosed in a position unsuitable for weight-bearing and cause endless trouble. The optimum position provides half an inch of equinus for boys, and somewhat more for girls to allow for the heel of the shoe; the forefoot must be correctly aligned with the ankle and knee, and the first metatarsal depressed slightly lower than the fifth to enable it to take the weight when walking.

Fixation may be by means of a metal splint or a plaster-of-Paris cast. A metal splint leaves the foot and ankle exposed for inspection so that abscesses can be detected early and sinuses treated if necessary. Plaster casts should be bivalved for the same purpose. Weight-bearing is permitted when recalcification is well advanced, but protection by a walking plaster or a walking iron is necessary for a further period.





Above. FIG 231 Tuberculous disease of the fi[illegible] metatarsal.

Left FIG 232 [illegible] disease of the ank[illegible] The pri[illegible] talus [illegible] of the tibia with a [illegible]

Operative. There is yet insufficient experience with chemotherapy for the indications for operation to be defined. In the old days the prognosis in children as regards both healing and subsequent function was quite good without the need for operative intervention, and now it is much better. In adolescents and adults, when the disease is well advanced before treatment is begun, excision of the affected bone or arthrodesis of the joint may lead to quicker healing. Amputation may be advisable in older people showing a poor response to conservative treatment, and when the tarsus is disorganized to such an extent that the ultimate function is likely to be worse than with an artificial limb

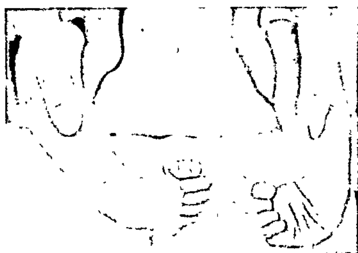


Fig 234 Congenital talipes equinovarus in a baby aged three weeks.

At birth the bones may be normal in shape and size, the deformed osition being held only by contracted soft tissues. In more severe cases, owever, the bones are distinctly smaller than normal and somewhat ... alus and calcaneus. ... s neck is longer and ... and the articular ... ed inwards, rotated nwards about its vertical axis, and the concavity of its inner surface is nore pronounced. The other bones are not greatly altered in shape although ccasionally the navicular is absent.

In untreated or unsuccessfully treated deformities in older children nd adults, the inwards and downwards deflection of the neck of the talus s increased, the exposed outer aspect of the head becomes rough and rregular, and the body of the bone wedge-shaped (*Fig.* 235). The axis of he superior articular facet of the calcaneus is rotated inwards, and the osterior end of the bone remains small reducing the size of the heel. The

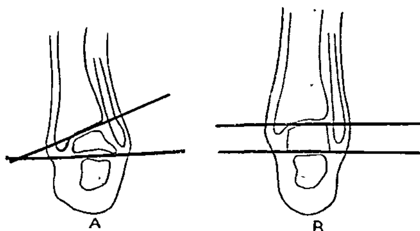


Fig. 235 ... Walsham and Kent Hughes). ... d weight-bearing

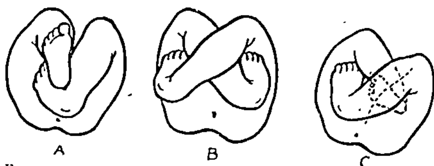


FIG 233 Abnormal intra-uterine positions of the feet (modified from Denis Browne).

into the instep of the other, or one heel is tucked into the opposite groin with the foot in calcaneo-valgus, or the toes are placed in the groin with the foot in equino-varus. Other deformities are explained by less frequent variations such as when the knees are hyperextended and the feet pressed against the forehead. New-born infants fold almost without help into the position they have occupied for so long in the uterus, and the corresponding moulding of the place against which the feet have been pressing is often obvious.

There are two clinical types of talipes—those that are comparatively easily cured and those that are extremely resistant to treatment. It is probable that the former are the result of defects in moulding. In the latter the muscles are atrophic and the joints stiff, and some additional factor must be postulated; Denis Browne explains them, although with less confidence, on a basis of increased mechanical pressure, but other surgeons consider they are due to a primary defect in the development of the muscles. It is possible to produce club foot (and other defects) in the experimental animal by interfering with the development of the fœtus. This can be done in several ways, for example, depriving it of oxygen or by injecting insulin, the nature of the defect depending on the precise age at the moment of interference.

TALIPES EQUINOVARUS

This deformity consists of inversion and adduction at the subtaloid and mid-tarsal joints, and in severe instances at the inter-tarsal, tarso-metatarsal and metatarso-phalangeal joints also. The appearance of the foot with its small, elevated heel, broad and twisted forefoot, and curved outer border is quite characteristic (Fig. 234). The movements are grossly restricted, even in the new-born, and the foot cannot be made plantigrade without considerable force.

Many infants with normal feet hold them inverted for a while after birth, but there is a full range of passive movements which allows the feet to be dorsiflexed almost until the toes touch the shins, and no treatment is necessary. Care must be taken, however, to recognize very mild talipes in which there is no real deformity but a little limitation of eversion and dorsiflexion. Such feet require immediate treatment, and they should not be left "to see how they develop" because correction then becomes difficult instead of being simple.

present. A majority of mild deformities, and some of moderate severity, can be fully corrected within a few weeks; all that is necessary is for the physiotherapist, or the mother, to ensure that full movements are retained until walking is commenced.

If full movements are not obtained within four weeks, a *Denis Browne splint* is applied. This ingenious instrument controls one foot by means of the other. It not only maintains efficiently the position already obtained, but it increases the range of movements by utilising the muscle power of the legs whilst kicking, and it also helps to reduce the internal torsional deformity of the tibia.



Fig 236 The first length of adhesive plaster is applied to the heel and second to the forefoot, both are carried around the knee

The method of applying the splint is shown in Fig. 237. The cross bar is removed and the leg-plates and the sole-plates are well padded with adhesive felt. First the feet are fastened to the sole-plates with adhesive strapping, then the legs are strapped to the leg-plates, and finally the cross-bar is screwed on and the angle of the feet is adjusted. If both feet are affected, they are turned out about 60°; if only one is affected, it is turned out a similar amount but the normal foot should point straight forwards. The splint requires adjusting every week or so, and its use is continued until full mobility is acquired.

Infants. When treatment is started immediately after birth the foot should become normal, if the result is going to be perfect, within a matter of weeks. [illegible] an be greatly improved by subsequent

navicular lies on the inner side of the head of the talus instead of in front of it, and the cuboid is displaced inwards also. There is gross thickening and contraction of the ligaments on the inner side of the foot and ankle, particularly those around the tuberosity of the navicular, and there is contraction of the tendo-Achillis, the posterior capsule of the ankle joint [illegible] fascia. Wasting of the muscles of the calf [illegible]

In many instances the tibia is rotated inwards about its longitudinal axis so that the external malleolus is advanced to the coronal plane, or even in front of the internal malleolus (p. 26). This causes the ankle to face slightly inwards, and even after the equinovarus has been corrected, the foot remains in the "intoeing" position.

Treatment

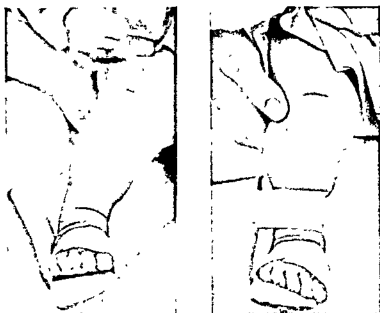
There is no standard treatment for this deformity, and although there are certain procedures in common use, the indications vary in different clinics. The methods described here are those ordinarily used by the writer.

There has been argument in the past as to the criteria of "cure," but no foot that is abnormal as regards shape, mobility or muscular development can be regarded as cured and it is undesirable to accept a lower standard. A perfect result can by no means always be achieved, and a prognosis cannot be given until the effect of treatment has been seen. As already indicated, there are two clinical types—those that can be cured, and those that are never fully corrected, or quickly relapse. It is probable that relapse only occurs when there has not been full correction, and that once complete mobility has been restored the foot develops normally without further treatment.

Babies. An early start is the first essential as a normal foot is otherwise unobtainable. *The best time to begin treatment is the first day of life.* For a short while the soft tissues are comparatively pliable, there is little or no change in the shape of the bones, and a perfect result is often possible. Adaptive changes in bones and ligaments occur during the first few months and to delay treatment inevitably makes the task harder.

The foot is manipulated to correct both equinus and varus elements of the deformity. Quite a lot of force is required and great care must be taken to avoid injury to the lower epiphyses of the tibia and fibula—it should be undertaken only by those with special experience of this work. After manipulation the foot is fixed in the greatest amount of eversion and dorsiflexion that can be held without impeding the circulation. This is conveniently done with adhesive strapping, one piece being passed around the heel and a second around the forefoot as illustrated in Fig. 236 (the same child as in Fig. 234). An anæsthetic is not essential at first, but it is most desirable if forcible manipulation is continued longer than a month.

It is unlikely that a full range of movements will be obtained at the first attempt and manipulation is repeated at intervals of three days until this is achieved. It is not sufficient merely to make the foot pl[illegible] because relapse is almost certain. [illegible]less full eversion and dorsiflexion [illegible]



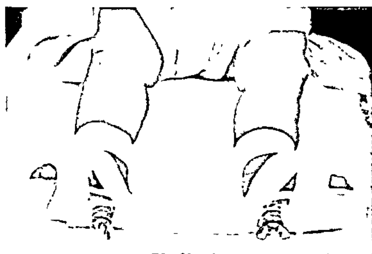


FIG 237 Applying Denis Browne's splint to an infant with bilateral talipes equinovarus The foot is strapped to the sole-plate before the leg-plate is fixed in position

measures and a reasonable functional result can nearly always be obtained by one means or another. It is, however, essential to get the maximum correction as quickly as possible to prevent the deformity of the bones increasing.

ever, obtained, and even if walking in plaster is encouraged, the foot gets stiffer, and wasting of the calf muscles increases. Soft tissue operations, such as Brockman's, which aim at dividing the contracted structures on the inner and plantar aspects of the foot to enable the bones to be swung into place are now seldom practised. Better results are obtained by the procedure described by J. Hiram Kite.

Kite's wedged plasters provide an ingenious method of correction that is both gentle and progressive, but although simple, it needs considerable practice. No anaesthetic is required. A plaster cast is applied whilst the foot is held in the best obtainable position; a wedge is then cut from the plaster, more correction is obtained and secured with a couple of turns of bandage. At intervals of a week, further wedges are removed and yet more correction is possible. It is most important not to attempt to correct more than one element of the deformity at a time, either the equinus, the varus or the metatarsus varus, and the wedge is positioned accordingly.

Older Children. Every foot can be made plantigrade and given useful function by some means. Kite's plasters are tried first, and if they fail, an operation involving bone is necessary. This is best postponed until the child is at least eight years of age when ossification is sufficiently advanced. There is little to be done during the interval except to hold such correction as has already been obtained and keep the foot as supple as possible. During the day a short inside iron, outside T-strap and outside wedges to both sole and heel of the shoe are worn; at night a metal splint is substituted.

The basic operative procedure is *Dunn's Triple Arthrodesis* (p. 315); the precise way in which the bones are trimmed varies and each operation is planned to suit the needs of the particular patient. A rotation osteotomy of the tibia is necessary as well when an internal rotational deformity persists in spite of the use of a Denis Browne splint (p. 27). This is best performed through the cancellous bone at the upper end of the tibia, care being taken to avoid damage to the anterior tibial vessels as they pass above the interosseous membrane.

The "boat-shaped" foot that is sometimes produced by forcible dorsiflexion of the forefoot at the mid-tarsal and tarso-metatarsal joints is not easily corrected by triple arthrodesis. This element of the deformity can be improved by lowering the head of the first metatarsal by removing from the base of the bone a wedge with its apex pointing upwards and replacing it with its apex downwards, and lowering the head of the fifth metatarsal by a similar operation on the cuboid.

CHAPTER VII

THE SHOULDER GIRDLE

PAIN IN THE SHOULDER, ARM AND HAND

PAIN referred to the shoulder, arm and hand is a common complaint which is conveniently included here because some of the more usual causes are associated with the shoulder girdle. Although pain is often the first symptom to present itself, and sometimes the only one, the complete syndromes can include objective sensory and motor changes caused by interference with the central or peripheral nervous systems, phenonema due to involvement of the sympathetic nervous system, and vascular disturbances. The following conditions may have to be considered in the differential diagnosis :—

Visceral Disease.	Pain referred to the shoulder from the pleura, pericardium or diaphragm all of which are supplied by the phrenic nerve (C3, 4 and 5).
Central Nervous System.	Neoplasms of the cervical cord and nerve roots—pain of root distribution may precede objective signs. Progressive spastic paralysis of any cause. Anterior poliomyelitis. Muscle dystrophies. Herpes Zoster.
The Spinal Column.	Spinal caries, neoplasm, fracture. Cervical Spondylosis.
Extra-Spinal Disease.	Pressure at the cervico-brachial junction. Carpal tunnel compression. Subacromial bursitis and other lesions of the shoulder.

The chief problem in diagnosis, and it may be difficult, is to differentiate between spondylosis, cervico-brachial pressure, carpal tunnel pressure and subacromial bursitis. The label "brachial neuritis" was formerly attached to many such cases when the ætiology was obscure, but it is now clear that primary brachial neuritis is rare and this diagnosis can no longer be used as a cloak to cover the lack of more precise knowledge.

Pain originating in the shoulder is sometimes secondary to cervical spondylosis, but whether due to this, or to one of the more usual causes,

TALIPES CALCANEUS

This deformity is considerably more common, if mild degrees are included, than is indicated in the table on p. 305. The milder degrees may be caused by one heel being tucked into the opposite groin during intra uterine life (Fig. 233c), and the more severe by some such position as that in which the knees are extended and the soles of the feet pressed against the face.

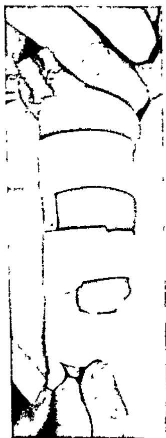


Fig 238

The deformity consists in acute dorsiflexion of the foot at the ankle and to a lesser extent at the mid-tarsal joint. Dorsiflexion is usually associated with eversion at the sub-taloid and mid-tarsal joints (*talipes calcaneo-valgus*), and less frequently with inversion at the same joints (*talipes calcaneo-varus*). There is little alteration in the shape of the bones at birth, the deformity being held only by soft tissue contraction. In a moderately bad case the foot cannot be plantar-flexed even to a right-angle without force, the tendons in front of the ankle stand out prominently, and there is no visible longitudinal arch. It should be possible to plantar-flex the normal foot at birth until the dorsum of the foot is in line with the shin and a slight amount of limitation must be watched for because correction is simple only if it is done at once.

Treatment

Treatment, as with talipes equinovarus, should be commenced on the day of birth whilst the soft tissues are still pliable. The foot is manipulated into a position of extreme equinus, and if there is also a valgus element, into moderate inversion. It is held in this position by a straight splint fixed to the front of the foot and leg with adhesive strapping (Fig. 238). The prognosis is good when treatment is commenced early and a perfect result is often obtained. The few resistant cases can be corrected later by operation.

present when there are no symptoms, some other factor must be present, and this is probably concerned with the posture of the shoulder girdle.

Pathological Anatomy

Ribs. The chief abnormalities, of which there are an unlimited number of variations, are :—

(*a*) An additional rib in connection with the seventh cervical vertebra ; it may be of any size from a rudimentary projection to a complete rib articulating with the first thoracic rib or sternum (Fig. 239). There may be a fibrous band which lies in the anterior border of the scalenus medius and extends from the tip of a rudimentary rib to the first thoracic rib (Fig. 240). Sometimes there is a large boss or exostosis on the first rib where it is joined by a cervical rib or a fibrous band.

(*b*) A rudimentary first thoracic rib which joins the second rib either directly or by a fibrous band.



FIG 240 Rudimentary cervical ribs At operation on the right side a fibrous band was found joining the tip of the rudimentary rib to the first thoracic rib

(*c*) Asymmetrical first thoracic ribs, usually in association with horaco-cervical scoliosis

Brachial Plexus. The size of the contribution from the component oots is variable. A post-fixed plexus contains a large element from the econd thoracic root.

Scalene Muscles. SCALENUS ANTERIOR. The costal insertion may be entirely tendinous, it may extend further backwards than usual, and it may have a sharp falciform edge extending posteriorly along the rib.

SCALENUS MEDIUS. The costal insertion, which is tendinous, may extend further forwards than usual on the first rib.

It is known that division of the scalenus anterior is sometimes followed by relief from symptoms whether an abnormal rib is present or not. The explanation has been much discussed. It is considered by some surgeons

it is always accompanied by some limitation of movement, or pain at the extreme of movement, or tenderness. When associated with spondylosis, both the neck and the shoulder should be treated.

Cervical spondylosis does not cause symptoms unless some abnormality is demonstrable in good quality X-rays, and even an acute intervertebral disc protusion, unlike a protusion in the lumbar spine, is most improbable in a radiologically normal neck. On the other hand, the presence of changes in the X-rays is not proof of the cause of the symptoms. Likewise, when pressure at the cervico-brachial junction is suspected, the presence of radiological changes is no more than presumptive evidence as to the diagnosis. Symptoms can only be attributed with certainty to either of these conditions, or to carpal tunnel pressure, when there are objective neurological signs. In the absence of such signs reliance must be placed on the history and the response to conservative treatment.



FIG 239 Bilateral cervical ribs The patient had symptoms in both arms which were relieved by resection of the ribs

PRESSURE AT THE CERVICO-BRACHIAL JUNCTION*

Certain symptoms in the arm and hand, notably paræthesiæ, pain and muscle wasting, are caused by interference with the neurovascular [illegible] yet others with typical symptoms have no abnormality of the ribs. A number of theories have been put forward in explanation but it is clear that no single cause can account for all cases. In a majority some variation in the arrangement of the ribs and other structures at the root of the neck can be demonstrated at operation, but since similar variations are often

* This title is given by E. D. Telford and S. Mottershead to their invaluable contribution in the *Journal of Bone and Joint Surgery* (1948, 30B, p 219) of which free use has been made here.

neurovascular bundle in an individual with normal anatomy. Depression of the shoulder girdle is, however, of importance because (1) it increases the distance covered by the lowest trunk of the brachial plexus, and in some circumstances, particularly when *an anatomical abnormality* is *present*, the tension on the plexus becomes great enough to produce symptoms, and (2) it causes compression of the axillary artery between the two heads of the median nerve (see below).

Axillary Artery. The radial pulse is diminished or obliterated in certain positions of the shoulder in many patients with a cervical rib, and

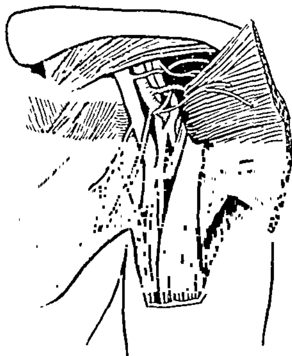


FIG 242 The relations of the axillary artery in 65 per cent of people (redrawn from Telford and Mottershead)

ı about 65 per cent of normal subjects. It is unlikely for the reasons lready stated that this phenomenon is due to compression of the axillary rtery between the first rib and the clavicle. Another explanation is given y Telford and Mottershead who found in a series of anatomical dissections hat the two heads of the median nerve, in the same percentage of bodies, ere so arranged that the axillary artery was compressed between them hen the shoulder was depressed, and in certain other positions of the arm Fig. 242). In the remaining bodies the arrangement was such that the rtery was unaffected by depression of the shoulder.

Thrombosis. Thrombosis of the brachial artery is an occasional nd grave complication of cervical rib, and in rare instances there is an neurysmal dilatation of the axillary artery distal to the rib which may be artly or completely thrombosed. The same authors consider both phenomena may be due to arterial spasm caused by irritation of the sympathetic erve fibres which are sometimes to be found in the lowest trunk of the rachial plexus where it passes over the first rib.

that this muscle, for an unknown reason, enters a state of spasm which elevates the first rib thus stretching the neuro-vascular bundle. This view is unsupported by evidence and it is more probable that the symptoms are attributable to anatomical variations in the arrangement of the scalene muscles. When the insertion of the scalenus anterior extends unusually far backwards at the same time that the scalenus medius extends forwards, the plexus is raised in the V between them (Fig. 241B). In other instances the lowest trunk of the plexus is compressed between the scalenus anterior and the first rib; this may happen when the insertion of the muscle is entirely tendinous, or when there is a boss on the first rib where a cervical rib articulates (Fig. 241A).

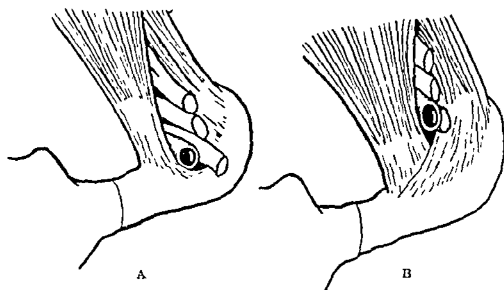


FIG 241 Variations in the arrangement of the insertions of the scalene muscles (redrawn from Telford and Mottershead).

Shoulder Girdle. Drooping of the shoulder girdle appears to be common during middle life, particularly in women, and it is accentuated by unaccustomed manual work or excessive fatigue. It is probable that this plays an important part in determining the onset of symptoms.

It has been argued by some writers that depression of the shoulder approximates the clavicle to the first rib, and that the neurovascular bundle is then liable to compression in the "costo-clavicular vice." This is disputed by Telford and Mottershead who have shown experimentally that :—

(*a*) When the arm is abducted or retracted the acromial end of the clavicle rises and moves backwards, and the clavicle rotates so that its concavity arches over the root of the neck. The distance between the clavicle and the first rib is increased.

(*b*) When the shoulder is depressed the acromial end of the clavicle moves downwards and forwards increasing the distance between the clavicle and the first rib.

(*c*) There is no such movement as downward and backward bracing of the shoulder.

If these observations are co[illegible] the clavicle cannot compress the

More severe pain, muscle atrophy and major vascular disturbances are indications for operation. Operation nearly always relieves pain; it also prevents muscle atrophy from occurring, or if already present from increasing, but existing wasting is not improved. The precise operative procedure cannot be determined in advance because the particular anatomical arrangement that will be encountered is uncertain. The root of the neck should be explored through an adequate incision by a surgeon familiar with the possibilities, and the lesion dealt with as necessary. This may involve excision of a cervical rib or a fibrous band, division of part of one or both of the scalene muscles, removal of a boss of bone from the first rib and occasionally excision of a segment of the first rib.

CERVICAL SPONDYLOSIS

Pain in the neck, around the shoulder girdle and in the arm and hand is due more often to a lesion of the cervical spine than to any other cause. The fashionable term "disc protusion" is inadequate to explain the complex symptomatology, and even when the pain happens to be of sudden onset, it does not mean that it is necessarily caused by a sudden protusion or herniation. A more satisfactory approach is to consider as a whole the syndrome now known as spondylosis without attempting to determine the particular element actually causing the symptoms in each case.

Spondylosis is particularly common in the cervical region, perhaps because of the great mobility of the neck and the many minor injuries to which it is subjected. It is not a single, well-defined entity, but a term used to describe the end-results of a number of different pathological processes taking place in the intervertebral discs. These are degenerative in nature and of the general type already described on page 92. The following features may be present, but not necessarily all in the same patient:

1. Narrowing of the intervertebral space.
2. Protrusion of a mass, at first consisting mainly of nucleus or mainly of annulus, which encroaches on the neural canal or an intervertebral foramen. The original tissues are slowly replaced by fibrous tissue which may become partly ossified.
3. New bone formation (osteophytes) occurring at the margins of adjacent vertebral bodies as a reaction to degeneration of the disc between them, and often fusing with an ossified protrusion.
4. Osteoarthritis of the posterior intervertebral joints
5. Inflammation and fibrosis of the meningeal sleeve investing the nerve roots. The sleeve may become adherent to neighbouring structures or form constricting bands around the nerve roots.

Symptoms are not always related to the pathological findings in an [illegible] use of pain. [illegible], and severe pain may be present when the radiological changes are but slight. This is partly because a cervical root normally occupies only about one-fifth

Clinical Types

Mild. There is complaint of burning, tingling and numbness in the hands, frequently both hands. The distribution is of the "glove" type, but it may extend up the forearm and upper arm to the shoulder. Symptoms are usually worse at night, and on waking in the morning the hand may seem "useless." Such complaints, particularly in middle-aged women, have been common since the early years of the last war when so many have undertaken unaccustomed manual work. In cases of this type the ribs are more often normal than abnormal, and it is probable that the symptoms are caused by depression of the shoulder girdle due to fatigue or strain. It is not certain if the symptoms are of nervous or vascular origin but their nature and distribution favours the latter.

Moderately Severe. In addition to sensations of numbness and tingling, there is definite pain and often wasting of the small muscles of the hand. Symptoms are frequently unilateral although the other arm may be affected at a later date. The pain comes on in spasms, sometimes almost abruptly, and it is usually worse at night. The distribution is of two types: in one, there is wasting of the thenar eminence and pain or paraesthesiae over the radial side of the hand and forearm; in the other, the hypothenar eminence and interosseous muscles are atrophied, the fingers become clawed, and there are sensory changes over the ulnar side of the hand and forearm and the inner side of the upper arm. A cervical rib or other structural abnormality at the root of the neck is more often present than absent.

Complete or partial paralysis of the serratus anterior causing winging of the scapula may accompany wasting of the muscles of the hand. Winging also occurs as an isolated phenomenon in the absence of other symptoms and is possibly caused by traction on the long thoracic nerve.

Symptoms due to sympathetic disturbance, such as intense sweating of the palm of the hand, have been observed occasionally and are sometimes the only complaint.

Very Severe. There are gross vascular changes and the pain is extremely severe. The brachial vessels may be thrombosed, and sometimes there is an aneurysmal dilatation of the axillary artery distal to the first rib. The dilatation may be partly occluded by thrombus from which fragments become detached causing embolic gangrene of the fingers. Dilatation of the axillary vein has also been observed. Walshe has recorded a complete Horner's syndrome which he considered was due to fibrosis around the stellate ganglion.

Treatment

Mild subjective sensory symptoms, whether they are associated with anatomical abnormalities or not, are often helped by exercises to strengthen the suspensory muscles of the shoulder girdle. The general health and nutrition of the patient should be investigated, and sometimes a change in occupation is desirable.

It is unusual for one structure to be involved alone and more often several, or even all, are concerned. The examination of every patient must be directed to all of them, and it is particularly important to exclude symptoms due to cord pressure.

Spinal cord. The spinal canal is comparatively narrow in the cervical region and even a small encroachment, if central, can press on the cord. A sudden, massive protrusion of a disc does occur occasionally, even as the result of a minor injury, and may cause paraplegia, quadriplegia or even death. More often the onset is gradual and the symptoms pass unnoticed, or



FIG 244 Changes in the fifth and sixth cervical vertebræ accompanying degeneration between them

here may be just a little muscle weakness or inco-ordination of gait. xamination at an early stage may show no more than an altered tendon eflex, but later all the signs of paraplegia may be present.

Symptoms. Symptoms seldom occur before early middle age and for ne most part they are restricted to the neck and upper limb. Involvement f the spinal cord is relatively uncommon, but it is most important that it hould be recognized before active treatment is prescribed or the result nay be serious.

The onset, in about one quarter of all patients, follows immediately fter an injury; in a similar number injury causes an exacerbation of ymptoms that previously were trivial, and a few can remember an injury nonths or years previously. Often the onset is very gradual and without

of the space in the intervertebral foramen, and therefore considerable encroachment on the space is possible without interfering with the nerve. Whether symptoms are caused or not probably depends on the precise situation of the nerve in the foramen, and this varies. Correlation between pathology and symptoms is made even more difficult by the fact that although the development of degenerative changes is usually gradual, there may be an abrupt onset of symptoms caused either by a sudden disc protrusion, or by an injury, often minor, that disturbs the relations of the nerve root.



FIG 243 Oblique view shewing spondylosis affecting the lower four cervical vertebræ and new bone encroaching on the neural foramen between the fifth and sixth.

Clinical Features

Any vertebra from the third to the seventh cervical may be affecte but most commonly the fifth, sixth and seventh, and more than one may involved at the same time. The physical signs vary according to the le and the precise anatomical relationships of the lesion to so great an exte that no attempt will be made to catalogue them. The main anatomic structures concerned should, however, be borne in mind. They are

1. *Spinal cord* pressure in the spinal canal.
2. *Nerve roots* pressure in the intervertebral foramina. fibrosis of the meningeal sleeves.
3. *Posterior joints* osteoarthritis.
4. *Muscles* myofascial painful areas (p.

It is unusual for one structure to be involved alone and more often several, or even all, are concerned. The examination of every patient must be directed to all of them, and it is particularly important to exclude symptoms due to cord pressure.

Spinal cord. The spinal canal is comparatively narrow in the cervical region and even a small encroachment, if central, can press on the cord. A sudden, massive protrusion of a disc does occur occasionally, even as the result of a minor injury, and may cause paraplegia, quadriplegia or even death. More often the onset is gradual and the symptoms pass unnoticed, or



FIG 244 Changes in the fifth and sixth cervical vertebræ accompanying degeneration between them.

here may be just a little muscle weakness or inco-ordination of gait. Examination at an early stage may show no more than an altered tendon eflex, but later all the signs of paraplegia may be present.

Symptoms. Symptoms seldom occur before early middle age and for he most part they are restricted to the neck and upper limb. Involvement f the spinal cord is relatively uncommon, but it is most important that it hould be recognized before active treatment is prescribed or the result nay be serious.

The onset, in about one quarter of all patients, follows immediately fter an injury; in a similar number injury causes an exacerbation of ymptoms that previously were trivial, and a few can remember an injury onths or years previously. Often the onset is very gradual and without

of the space in the intervertebral foramen, and therefore considerable encroachment on the space is possible without interfering with the nerve. Whether symptoms are caused or not probably depends on the precise situation of the nerve in the foramen, and this varies. Correlation between pathology and symptoms is made even more difficult by the fact that although the development of degenerative changes is usually gradual, there may be an abrupt onset of symptoms caused either by a sudden disc protrusion, or by an injury, often minor, that disturbs the relations of the nerve root.



FIG 243 Oblique view shewing spondylosis affecting the lower four cervical vertebræ and new bone encroaching on the neural foramen between the fifth and sixth.

Clinical Features

Any vertebra from the third to the seventh cervical may be affected, but most commonly the fifth, sixth and seventh, and more than one may be involved at the same time. The physical signs vary according to the level and the precise anatomical relationships of the lesion to so great an extent that no attempt will be made to catalogue them. The main anatomical structures concerned should, however, be borne in mind. They are

1. *Spinal cord* pressure in the spinal canal.
2. *Nerve roots* pressure in the intervertebral foramina. fibrosis of the meningeal sleeves.
3. *Posterior joints* osteoarthritis.
4. *Muscles* myofascial painful areas (p. 49).

compression test may be positive. This test consists in bending the neck towards the painful side and pressing on the top of the head; when positive it causes pain in the arm.

In a majority of patients the symptoms are comparatively slight and there are no objective motor or sensory changes. These must, however, be looked for in every case, and they will often be found when the symptoms are severe. The tendon reflexes in the arms may be exaggerated or diminished; and when there is cord pressure, the reflexes in the legs are increased and the plantar responses are often extensor. Sensory changes such as impairment of light touch and pin-prick, and having a segmental distribution, may be found in the upper limbs, and sometimes also in the lower, and there may be loss of appreciation of passive movement.

The cerebrospinal fluid is usually normal in content although there is sometimes a small increase in the proteins. There is seldom any change in pressure on jugular compression.

Pain and limitation of movement at the shoulder are not uncommonly present in long-standing cases, but the significance is not properly understood. The shoulder should always be examined because it may be the immediate cause of some of the pain, and then relief can be given by treatment.

X-rays. (Figs. 243 and 244) A full investigation involves an antero-posterior view, lateral views with the neck erect, flexed and extended, and left and right obliques. The findings include narrowing of the inter-vertebral space, new bone encroaching on the spinal canal or intervertebral foramina, forward shift of a vertebra on the one below it during flexion, and osteoarthritis of the posterior intervertebral joints. Myelography may be necessary when compression of the cord is suspected to determine the level and extent of the lesion.

Treatment

A large proportion of patients with symptoms only in the neck and upper limbs respond satisfactorily to conservative treatment. When the symptoms are mild, manipulation often gives relief. It is, however, essential to make certain that there is no evidence of pressure on the spinal cord; I have not heard of harm resulting provided this precaution has been taken. No anæsthetic is used and the neck is manipulated two or three times a week by the method described on page 48.

When the symptoms are more severe, or when there are signs of involvement of nerve roots or the spinal cord, rest is indicated. A cervical collar may be tried first. This is rather an unpleasant contraption to wear and a patient's willingness to accept it is an indication of the severity of the pain—some get such relief that they voluntarily keep it on at night. A number of patterns are available; one of the less uncomfortable is made of perspex and fashioned to a plaster cast (Fig. 245). The collar usually has to be worn for several months and is given up gradually as the pain subsides.

The next step, if a collar fails to give relief or is unacceptable to the patient, is rest in bed. Only two pillows are permitted, and sedatives are

relation to the trauma, and it may be many months before advice is sough

The first complaint may be of pain, paræsthesiæ or weakness in th order of frequency. The distribution varies with the level of the lesion.

Pain. A common history is of recurring attacks of pain and stiffne of the neck which at first is indistinguishable from the ordinary "st neck" due to other causes, but later it radiates more widely. Sometim pain is first felt in the muscles of the shoulder girdle, for example, tl trapezius, latissimus dorsi or pectoralis major, or in the overlying ski and sometimes in the arm or hand. A typical distribution is from the poi of the shoulder and down the outer side of the arm to the elbow. The pa may be made worse by movement of the neck, by active use of the arm, by coughing and sneezing.



FIG 245 Cervical collar made of perspex

Paræsthesiæ. There may be complaint of numbness and tingling in t fingers, hand or forearm of one or both limbs, or of the hand feeling nun cold and blue. It tends to be worse at night and patients often say tl they get up several times during the night and walk about. Difficulty using the hand may be experienced on first waking in the morning.

Weakness. This may be a prominent symptom, even in the absence pain. It affects most often the small muscles of the hand, and sometin the muscles of the upper arm and shoulder girdle. Occasionally the lo limbs are affected to a greater extent than the upper and then the compla may be of difficulty in walking straight, or falling unexpectedly.

Physical Signs are sometimes remarkable for their absence but of there is tenderness over the spinous processes at the level of the lesi and gentle percussion may cause pain referred to the arm. The foram

combination of signs is almost diagnostic of a median nerve lesion at the level of the wrist. Sometimes there are typical symptoms but no physical signs or, at most, doubtful impairment of sensation; the diagnosis then rests on the history, the exact distribution of paræsthesia and the absence of another cause.

Treatment. Mild symptoms often disappear spontaneously in the course of a few months without treatment. Operation is indicated when use of the hand is interfered with, and when there are positive neurological signs. All that is necessary is to divide the flexor retinaculum through a transverse skin incision; any causative lesion such as a ganglion, infective tenosynovitis or an exostosis should be dealt with at the same time. The part of the median nerve lying beneath the ligament may appear to be somewhat flattened, but this is not always very convincing, and proximally it may be a little congested and swollen.

STIFF AND PAINFUL SHOULDERS

Lesions around the shoulder joint are amongst the commoner causes of pain in the hand, arm and shoulder girdle. The modern conception of the pathology has developed from the pioneer work of Codman of Boston, and although many problems still remain unsolved, correlation between the pathological and clinical findings is now close enough to be of assistance in planning treatment.

Movements

Elevation of the arm to the vertical position involves movement at no less than five different sites, three of which are properly constituted joints and two are not. They are:—

1. *The gleno-humeral joint.*
2. *The acromio-humeral, or "bursal joint."*
3. *The scapulo-thoracic mechanism.*
4. *The acromio-clavicular joint.*
5. *The sterno-clavicular joint.*

The gleno-humeral joint, or shoulder joint proper, suffers from few ills. It is a shallow ball and socket joint with a loose capsule and a wide range of movements. No part of the capsule is tense within the ordinary working range, and therefore sprains are rare. The forces operating on the joint, for example the weight of the limb, are usually such as to distract it, not compress it, and this may explain why it is rarely affected by osteoarthritis.

A peculiarity of the shoulder is that movement at the gleno-humeral joint is necessarily accompanied by movement of the head of the humerus relative to the acromial process, this takes place at the "bursal joint" (Fig. 249). For practical purposes there is a double joint, and any condition preventing movement at one part must also prevent movement at the other part. Chronic pain and stiffness, however, are nearly always caused by a

given as necessary. If pain persists after a few days, traction with a weight of 3–5 lbs. may be applied to the head. This need seldom be maintained for longer than a week, but rest in bed should be continued for a further fortnight whether or not the symptoms have been relieved earlier. A few patients continue to have some pain after this time and may need a cervical collar.

Associated lesions such as myofascial painful areas (p. 69) and stiff and painful shoulder (p. 334) are treated by the appropriate methods. It is important to give them separate attention because they may be the cause of much of the pain.

Operation is the last resort and fortunately is not often necessary. The indications are very severe pain that has failed to respond to conservative treatment, and paralysis due to pressure on the spinal cord that is increasing in spite of treatment. The operation is one of extreme difficulty and a worth-while result is obtained in fewer than half the patients.

CARPAL TUNNEL COMPRESSION

This syndrome, which was first identified by Russell Brain in 1947 results from compression of the median nerve as it lies beneath the flexor retinaculum in front of the wrist. It gives rise to symptoms that may be difficult to distinguish from those due to cervical spondylosis and to cervico-brachial pressure.

It is often impossible to determine the cause but sometimes the pressure is clearly due to some pathological condition which diminishes the available space in the rigid carpal tunnel. Such conditions may be associated with the flexor tendons, for example tenosynovitis, or ganglion; or they may be in connection with the bony wall of the carpal tunnel. Examples of the latter are dislocation of the semilunar bone, osteoarthritis, rheumatoid arthritis and the thickening of bone occurring in acromegaly.

The syndrome occurs most often in middle-aged women but younger and older people, and also men, may be affected. The prinicpal complaint is of burning, tingling, numbness or "pins and needles" in the fingers, and sometimes that the fingers feel as if they were swollen. Since only the median nerve is involved, the little finger escapes and many patients are aware of this when they are asked. There may be pain in the forearm, and even in the arm above the elbow, but it is seldom severe. The symptoms can be intermittent or constant : they are made worse by energetic use of the hand, and they are nearly always more troublesome at night, often interrupting sleep after a few hours. On waking in the morning the hand is clumsy and difficult to use for some minutes. Hanging the arm over the side of the bed may give partial relief, as may rubbing the fingers and moving them about.

The physical signs, when the condition is well developed, consist in impairment of sensation of the thumb, forefinger, middle finger and half the ring finger, wasting of the outer half of the thenar eminence and weakness of the abductor pollicis brevis and opponens pollicis muscles. This





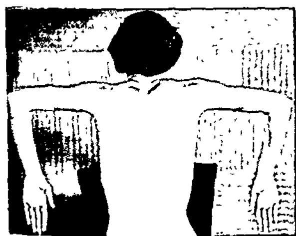


FIG. 246 The limit of abduction of the arms

Top left: In neutral rotation

Top right In external rotation.

Left. In internal rotation



FIG 247. The limit of elevation of the arms in the sagital plane

Left.
In external rotation.

Right
In internal rotation.



Note the apparent paradox that the final position of the arms is the same when they are elevated in the sagital plane in internal rotation and when they are abducted in external rotation

lesion of the "bursal joint," and very seldom by disorders of the gleno-humeral joint.

It is necessary to distinguish between gleno-humeral and scapulo-thoracic movement during elevation of the arm. The scapula does not lie in the coronal plane but makes an angle of about 30° with it. True abduction takes place in the scapular plane and it is in this plane that movements should be tested. Scapulo-thoracic abduction amounts to about 60° (not 90° as is commonly stated). Gleno-humeral abduction varies in extent with the rotation of the humerus because, in some positions, the tuberosities of the humerus impinge on the acromion and the coraco-acromial ligament. In full internal rotation the range of gleno-humeral abduction is about 60°, and in full external rotation it is more than 120°. Consequently, when the arm is internally rotated, it can only be raised a little above the horizontal (by combined scapulo-thoracic and gleno humeral movement), whilst in external rotation it can be raised to the perpendicular (Fig. 246). Appreciation of this point is of importance both when examining the movements of the shoulder and when manipulating it under an anæsthetic.

It should be noticed that rotation has a contrary effect when the arm is raised in the sagittal plane (flexion). Full elevation is possible only in internal rotation, and in external rotation it is restricted to about 135° (Fig. 247).

Elevation of the normal arm does not consist of two distinct movements, first at the shoulder joint and then at the scapula, but both occur synchronously. This is refe :
The rhythm is disturbed in

The function of the supraspinatus muscle is of some clinical importance. It was formerly thought that the supraspinatus initiated the movement of abduction, and the deltoid completed it. This is not so because, when there is complete rupture of the supraspinatus, active abduction is still possible although difficult, provided pain is inhibited by infiltration with novocain. It is probable that the action of the supraspinatus is to depress the head of the humerus in the glenoid during abduction and thus prevent the tuberosities coming into contact with the acromion and the coraco-acromial ligament; the supraspinatus also fixes the head to enable the deltoid to make use of the maximum leverage.

Ankylosis of the acromio-clavicular joint has no demonstrable effect on the function of the arm and the usual anatomical teaching that abduction is restricted is not correct. An ankylosed sterno-clavicular joint, however, restricts scapular movement slightly and prevents full elevation of the arm.

Pathological Anatomy

The Musculo-Tendinous Cuff. The four short rotator muscles of the shoulder, i.e. the supraspinatus, infraspinatus, teres minor and subscapularis, surround the joint on three sides, only the inferior aspect being uncovered. The tendons of these muscles are inserted partly into the

Calcification does not take place within the bursa, as Codman once suggested and later denied. Frequently, however, a calcified deposit in the musculo-tendinous cuff bursts into the bursa bringing about a spontaneous relief of symptoms; the calcified material is then rapidly absorbed.

3. Partial Rupture of the musculo-tendinous cuff, almost always the supraspinatus portion, is of considerable clinical importance. It usually occurs in tendons that have already begun to degenerate and may therefore be caused by comparatively trivial injuries. A tear of the deep fibres of the tendon probably produces few symptoms, but a tear of the superficial fibres necessarily involves the floor of the bursa and causes it to become inflamed.

4. Complete Rupture of the musculo-tendinous cuff is usually due to trauma, but it may also occur gradually as the result of a process of *attrition* without causing acute symptoms. The supraspinatus portion of the cuff is

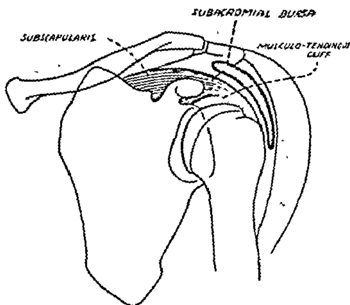


Fig 249 The relations of the subacromial bursa

most frequently affected, but the tear may extend into the infraspinatus and subscapularis portions. The rent in the cuff forms a communication between the joint and the bursa, and the head of the humerus is exposed. In the course of time the articular cartilage becomes eroded over this area, and there may also be some peripheral new bone formation giving the appearance of osteoarthritis.

The Subacromial Bursa (Fig. 249). The structures around the shoulder are arranged in two distinct layers (the "bursal joint"). The deep layer consists of the musculo-tendinous cuff and the upper part of the shaft of the humerus; the superficial layer is composed of the deltoid muscle, the under-surface of the acromion, the coracoid process and the coraco-acromial ligament. Between the layers is interposed the subacromial (subdeltoid) bursa.

The subacromial bursa is a large complicated structure with processes

tuberosities of the humerus and the sulcus between the tuberosities and the articular surface, and partly into the distal portion of the capsule. They are joined to the capsule so intimately that they can only be separated by cutting and the conjoined tendons and capsule are known as *the musculo-tendinous cuff*, or *rotator cuff*.

Degenerative changes in the cuff are very common after middle age and are almost the rule in manual workers during later life. The cause is not certain but it is probable that trauma is usually responsible. The supraspinatus portion of the cuff is most frequently affected. It is inserted into the highest part of the tuberosity of the humerus and is particularly exposed to repeated minor injuries because it impinges on the acromion and coraco-acromial ligament when the arm is abducted in *internal* rotation.



FIG 248 Calcified deposit in the musculo-tendinous cuff

The following changes are known to occur in the cuff :—

1. HYALINE DEGENERATION of the tendinous fibres is the earliest pathological change that has been recognized. As the condition progresses and this does not always happen, the entire cuff, the joint capsule and even the biceps tendon are gradually involved. The tissues become œdematous and there is a diffuse round-cell infiltration followed by fibrosis which reduces or prevents all movements at the joint.

2. CALCIFIED DEPOSITS (Fig. 248) are frequently found in the degenerate tissues of the cuff, but it is not certain that degeneration is an essential pre-requisite to calcification. Some calcified deposits are microscopic in size, others are large enough to show in radiographs as pin-head opacities, and yet others grow to considerable dimensions. A medium-sized deposit can be seen at operation projecting through the musculo-tendinous cuff into the floor of the bursa and looking like a pimple with a yellowish centre surrounded by a red ring of hyperæmia. The deposit is often under tension and on incision the inspissated material is extrudated like tooth-paste from a tube.

The clinical features of acute lesions are distinctive and an accurate diagnosis is usually possible. It is important for the correct diagnosis to be made at once because the prospect of rapid recovery is greatly improved by early treatment. As already explained, nearly every lesion may cause chronic inflammatory changes in the subacromial bursa; the symptoms are then similar whatever the nature of the primary lesion and treatment is difficult and uncertain. Many patients have been condemned to months of pain because a minor injury of the shoulder was first treated by rubbing with embrocation and resting the arm in a sling.

Radiological examination is always necessary, not only to confirm or exclude the presence of calcified deposits, but also to exclude tuberculosis and other diseases of bone. Osteoarthritis of the gleno-humeral joint is most uncommon. Myofascial tender areas are not infrequently encountered in the trapezius and deltoid muscles; they are recognized by their comparatively superficial situation and the response to infiltration with novocain. Tuberculosis is suggested by gradually increasing stiffness with little pain but gross muscular wasting.

Complete Rupture of the Cuff

It is probable that this lesion is not uncommon but it is often misdiagnosed and the real incidence is unknown. It occurs typically in middle-aged or elderly manual labourers, but it is also encountered in younger men, in women and in sedentary workers.

The shoulder has usually caused no previous trouble until it is injured by a minor accident such as a fall on the outstretched hand, or a slip when lifting a heavy object. A sharp pain is felt at the time of injury, it gets steadily worse during the next few hours, and by night-time it becomes intolerable and sleep is impossible. The pain may be referred to the neck and down the arm to the hand.

On examination, the arm is held to the side and cannot be abducted actively. Nearly a full range of passive movements can be obtained with care, but this is painful and the pain is greatest as the tuberosity of the humerus passes under the acromion. There is marked tenderness over the cuff, and it may be possible to feel a gap at the site of the tear. Infiltration with novocain abolishes the pain; it also increases the range of active movements, some abduction then being possible although it is weak and cannot be held against pressure.

The symptoms tend to diminish with rest; after a few weeks the patient perhaps returns to work but this soon brings a return of severe pain, particularly during the night. The bursa becomes greatly thickened, sometimes distended with fluid, and the condition becomes predominantly one of chronic subacromial bursitis (see below).

Treatment. The prognosis is fair if the tear is sutured within a few days, but it is bad if operation is delayed even for some weeks. When the diagnosis is in doubt it is better to err on the side of excessive zeal and explore the shoulder. Little harm is done if the rupture proves to be only partial, but if a complete rupture is found, the small exploratory incision

extending under the coracoid process and the neighbouring muscles. It communicates with the joint only in pathological conditions (many subjects for anatomical dissection are elderly and anatomists express a contrary view). It has smooth, glistening inner surfaces which glide freely over one another, and it does not normally contain a demonstrable quantity of fluid. The deep layer of the bursa is closely adherent to the musculo-tendinous cuff and the superficial layer to the under surface of the acromion, and therefore, when the walls of the bursa are inflamed or adherent to each other, movement of the humerus is restricted.

Inflammation is nearly always secondary to a lesion of one of the structures lying in contact with the deep layer of the bursa. It may, therefore, be caused by any of the disorders of the musculo-tendinous cuff described above, and by fracture or disease of the upper end of the humerus. The inflammatory changes are similar to those occurring anywhere else; the inner surfaces of the bursa become red and rough, fluid is excreted, fibrin is deposited, and adhesions are formed. Later the walls become thickened, occasionally to as much as 2 or 3 mms., and the bursa is distended with fluid.

It is doubtful if primary bursitis occurs with any frequency. Stiff and painful shoulders of gradual onset in patients of early middle age are often attributed to "rheumatic" or "toxic" inflammation of the bursa and periarticular tissues. The balance of opinion, however, is against any such localized "rheumatic" manifestation.

The Biceps Tendon. The tendon of the long head of the biceps arises from the scapula just above the glenoid cavity; it passes across the upper part of the j[illegible]
tuberosities, [illegible]
It is not connected with the capsule but is invaginated into the synovial membrane, a sheath of which extends down the tendon towards the belly of the muscle for some two inches. The tendon does not move when the biceps contracts provided the shoulder joint is kept still, but movement of the humerus relative to the scapula is always accompanied by movement of the tendon in the bicipital groove.

Degenerative changes similar to those in the muscle-tendinous cuff are common during middle age. The tendon frays where it angulates around the upper [illegible]
Adhesions [illegible]
relative to the tendon (and therefore at the gleno-humeral joint as well), making it painful. In young people the healthy tendon is occasionally sprained by a violent traction injury.

Clinical Types

The following types may be distinguished :-

Complete rupture of the cuff.
Partial rupture of the cuff.
Calcified deposits in the cuff.
Chronic subacromial bursitis.

Treatment. Early active treatment is essential to prevent the shoulder becoming stiff. If the pain is bad, the arm is kept in a sling for a few days. Passive movements through the greatest possible range should be given once daily, the arm being held as shown in Fig. 251 to permit relaxation. Infiltration with novocain immediately before commencing

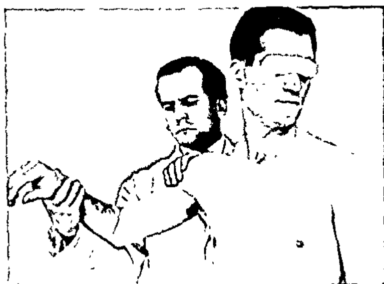


Fig. 251

treatment is of great assistance when there is much pain. Active movements, as described on p. 336, should be commenced as soon as possible—at once, if a local anæsthetic is used.

Calcified Deposits

These usually occur in the supraspinatus portion of the musculo-tendinous cuff, and less frequently in the subscapularis and infraspinatus portions. The deposits are often symptomless and may only be discovered during radiological examination for some other condition.

Symptoms are caused when the deposit impinges on the floor of the subacromial bursa. Occasionally the onset is rapid, but as a rule there is at first only an occasional pain or ache in the shoulder. Later abduction becomes painful, typically during the mid-part of the range only, and the remainder of the movement is painless; active movements are restricted to a greater extent than passive. There is tenderness over the affected area.

Inflammatory changes often develop in the bursa after a time and give rise to symptoms of chronic bursitis which merge with those due to the calcified deposit. Not infrequently, however, there is spontaneous rupture of the deposit into the bursa with immediate and lasting relief.

Treatment. The presence of a calcified deposit causing symptoms is an indication for operation (p. 328). Although spontaneous cure may occur, there is no way of telling if this will be in days or years and most patients are glad enough to accept an operation rather than face an uncertain period of pain and disability. Treatment is unnecessary when deposits are discovered by chance and there are no symptoms.

can be extended and the tendon repaired. After repair the arm is fixed in a plaster spica in a position of abduction 90° and external rotation 45°. A lid is removed from the plaster over the arm three weeks later and movements are commenced (Fig. 250). The plaster is not discarded until active elevation of the arm is possible, probably about ten to twelve weeks.



Fig 250 Note that the humerus is in the scapular plane (cf. Fig 261)

Chronic lesions are treated as for chronic subacromial bursitis. The response to conservative measures is often [illegible] acromion sometimes helps and is worth a tr[illegible] only method of relieving the pain.

Partial Rupture of the Cuff

Codman found this lesion in a large percentage of autopsies on elderly people. It is much more frequent than is generally recognized and is one of the common causes of pain in the shoulder of sudden onset. It usually occurs, sometimes without noticeable trauma, in tendons already weakened by degeneration.

The history resembles that in complete rupture. A sharp pain is felt in the shoulder which gradually gets worse and may be referred down the arm. Active abduction up to about 60° without pain is often possible, and there is a fair range of movements in the stooping position with the arm hanging free. Manual depression of the head of the humerus in the glenoid increases the range of passive abduction. There is tenderness over the supraspinatus portion of the cuff. Infiltration with novocain relieves the pain and restores almost full movement with good power; this is a valuable diagnostic and therapeutic procedure.

There is a greater liability to adhesive bursitis after partial rupture than after complete rupture, and treatment must be commenced early or the condition rapidly deteriorates and becomes chronic. The symptoms, signs and treatment are then as for chronic subacromial bursitis.

humerus is raised laboriously. When testing passive movements there should be complete muscular relaxation and the scapula is fixed with one hand whilst the arm is slowly lifted with the other, as shown in Fig. 251.

TENDERNESS. There is always tenderness over the site of the primary lesion, and if the bursa is greatly inflamed or distended with fluid, the whole region is tender. In supraspinatus lesions, and these are the commonest, tenderness is localized to a point just below the acromion and a little towards the front of the shoulder. Rotation of the humerus whilst pressure is maintained moves the tender spot from under the examining finger, and this establishes the fact that the lesion is in the rotator cuff or the bicipital groove and not in the superficial muscles.

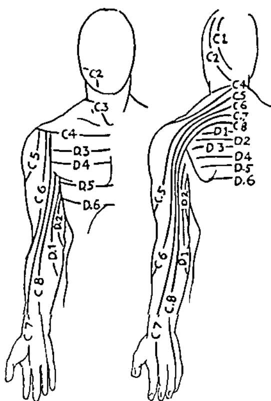


FIG 252 Cutaneous distribution of the cervical nerve roots (after Bing)

WASTING. Some wasting of the supraspinatus and infraspinatus muscles occurs fairly early in severe cases, but it is not conspicuous and is hard to see in fat patients. Wasting of the deltoid is seldom noticeable until late. Gross wasting with a stiff but comparatively painless shoulder is characteristic of tuberculosis.

Treatment. Owing to the varying nature of the primary lesion, treatment is uncertain and it is difficult to give an accurate prognosis. Some patients respond well but others are more resistant, and although ultimate recovery is the rule, severe lesions may take as long as a couple of years. The prognosis with untreated complete rupture of the rotator cuff is rather gloomy and there may be permanent pain and incapacity.

Chronic Subacromial Bursitis

This term is used as a matter of convenience to describe the late stage of the conditions already considered, as well as the late stage of "primary" degeneration of the rotator cuff or the biceps tendon, because subacromial bursitis is a prominent feature in all of them. The clinical picture when fully developed is similar whatever the cause and the nature of the primary lesion can only be guessed. Terms like "capsulitis" and "frozen shoulder" are better avoided because they suggest a pathology that is not necessarily present.

Signs and Symptoms. The outstanding features are pain, limitation of movement and tenderness.

PAIN. When the onset is gradual, pain is first felt deep in the shoulder, and it is often referred to the region of the insertion of the deltoid as well. It increases slowly in intensity and becomes noticeable on movements involving abduction and external rotation, such as doing the hair. Sometimes pain is experienced only over part of the range of abduction, usually about 45° to 90°, movement below and above being painless; this is typical of a localized lesion of the cuff such as a calcified deposit.

In time the pain may become so severe as to be almost unbearable. It radiates up the neck, into the shoulder blade and down the arm, wrist and fingers. The arm is held with the elbow to the side and the hand across the chest, a position of adduction and internal rotation. Interference with sleep at night is characteristic and this is often the complaint that troubles the patient most.

The muscles around the shoulder are supplied by the fifth to eighth cervical roots, and pain may be referred anywhere within the cutaneous distribution of these roots (Fig. 252). Pain in the hand is most frequently felt in the ring and middle fingers. Pain at the insertion of the deltoid is almost pathognomonic of subacromial bursitis. The distribution of pain has often lead to an erroneous diagnosis of "brachial neuritis" but the mistake can be avoided by examining the shoulder whenever there is pain in the arm or hand. The differential diagnosis from other causes of pain in the arm is discussed on p. 313.

LIMITATION OF MOVEMENT may be slight at first, only the extreme of one movement being checked by pain. It increases as the walls of the subacromial bursa become adherent and adhesions form in the musculo-tendinous cuff or around the biceps tendon, until finally all movement at the gleno-humeral joint may disappear. Most patients are wary of actions requiring abduction or external rotation—when undressing they remove the good arm first from their coats and shirts. Active movements are often restricted to a greater extent than passive.

Examination of the range of movements requires care because scapulo-thoracic movement may mask gleno-humeral. The patient should be undressed to the waist and viewed from behind. The scapulo-humeral rhythm is altered in all but the mildest cases, and instead of the arm and shoulder moving harmoniously, the scapula is elevated f... and then the

results are similar to those with radiotherapy in that there is often relief from pain, and sometimes there is resolution of the disorder with return of function. Cortisone is given by a single injection of 100–200 mgms daily for a week. ACTH can also be given by injection, the quantity being 25 mgms four times a day for one to two weeks. Physiotherapy is continued and, if necessary, the shoulder may be manipulated.

A local injection of hydrocortisone 25 mgms, repeated once or twice if necessary, can be most helpful in clearing up residual, accurately localized tender areas in the rotator cuff.

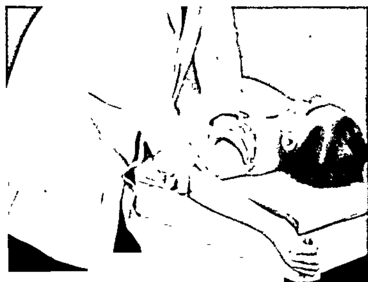


FIG 254 When manipulating the shoulder external rotation must precede abduction.

MANIPULATION under anæsthetic is helpful after the acute symptoms ve subsided, but if performed too early it often aggravates them. The st results are obtained when only one or two adhesions give way, and e worst results when the shoulder moves with a nasty feeling like rubbing :t wash-leather. A useful indication of the best time to manipulate is ıen the patient can sleep lying on the affected side. With very stiff joints ıs better to repeat the manipulation several times obtaining only a few grees of movement at each, than to move the shoulder through the full nge at one session and produce a severe reaction.

During manipulation it is important to remember the normal movement of the shoulder because serious damage to the capsule may be ıused by forcible abduction without the corresponding amount of ex-rnal rotation. The patient lies supine throughout the procedure. The rst movement is distraction ; the operator's knee is placed against the xillary border of the scapula and traction exerted in the longitudinal axis f the humerus. Next, the scapula is fixed by pressure with one hand and ıe humerus is moved first into internal rotation, and then into external otation and abduction (Fig. 254). The arm should be held by the elbow,

The usual practice is to start with the milder and simpler forms of treatment and progress, if needs be, to the more onerous. Physiotherapy is tried first and many of the less severe lesions respond well. When there is no benefit, radiotherapy is usually desirable before proceeding to manipulation. Operation is only advised as a last resort when all other methods have failed.

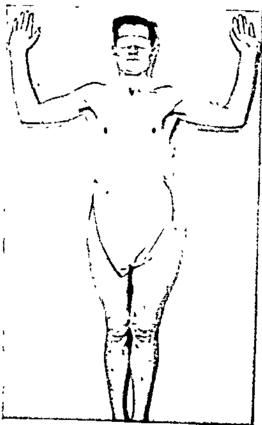


Fig 253

Physiotherapy. Heat in any of its forms does not appear to be of great value although muscle spasm may be reduced by warming the shoulder with an infra-red lamp and massaging the superficial muscles. Short-wave diathermy occasionally helps, but often it intensifies the pain.

Movements, both active and passive, play an important part in treatment. Passive movements are carried out as described on p. 333. Free swinging, which is almost a form of passive movement, is valuable when the shoulder is really stiff; a 2 lbs. weight is tied to the patient's wrist, he leans forward until the trunk is horizontal and then sways to make the arm swing like a pendulum At a later stage active exercises with a rope and overhead pulley, and with a towel, as in drying the back, are begun.

It is unusual for pain to be relieved completely and permanently until the full range of movements has been restored. It is easy to be deceived about the return of gleno-humeral movement because it is partly masked by scapulo-thoracic movement. A useful check, and also a good exercise, is as follows : the patient stands with his back to a wall and keeps his heels, buttocks, shoulders and elbows in contact with it whilst he abducts both arms to 90° and then externally rotates them—he should be able to touch the wall with the backs of the hands (Fig. 253).

Radiotherapy, although the reason is not really understood, gives rapid relief from pain to about half the patients; sometimes it seems to be responsible for initiating resolution of the degenerative process and normal function returns slowly. Treatment is given every day for two weeks, the total dose being about 1200r. Physiotherapy is continued meanwhile, and towards the end of the course, or soon after, manipulation may be helpful.

Cortisone or ACTH are worth a trial in the more resistant cases but the usual precautionary investigations to exclude the presence of pulmonary tuberculosis, peptic ulcer and so on must be made first. The clinical

of the arm. The articular cartilage is removed from the opposing surfaces of the joint. Fixation may be with a long screw, reinforcement being obtained from the acromial process which is "broken" downwards and its tip implanted into the greater tuberosity. Alternatively Charnley's compression arthrodesis may be used, the proximal nail being passed through the clavicle and the spine of the scapula, and the distal nail through the upper part of the shaft of the humerus.

RECURRENT DISLOCATION OF THE SHOULDER

This is a condition in which dislocation of the gleno-humeral joint recurs with some frequency. The initial dislocation is clinically indistinguishable from an ordinary dislocation sustained perhaps at football, or during an epileptic fit, but instead of recovering as usual the joint re-dislocates from time to time. Re-dislocation occurs without great violence when abducting or extending the arm, even during such ordinary movements as brushing the hair. It may happen only at widely-spaced intervals, or it may be so frequent as to interfere with ordinary activities. The patient is often able to reduce a re-dislocation himself, or with amateur assistance, but sometimes an anæsthetic is required.

Pathological Anatomy

The typical lesion as seen at operation consists in a separation of the antero-inferior portion of the glenoid ligament from the glenoid cavity. Sometimes the capsule is detached from the glenoid ligament, the latter remaining joined to the bone, and sometimes the ligament is free from both capsule and bone, rather like a bucket handle tear of the internal meniscus of the knee. There is usually a well-defined area in front of the neck of the scapula and beneath the subscapularis muscle into which the head of the humerus is displaced when it is dislocated. A somewhat similar defect in the attachment of the antero-inferior portion of the capsule is known to occur in a high proportion of apparently normal people, but the exact significance of this in relation to the ætiology of recurrent dislocation is still uncertain.

The reason why some dislocations of the shoulder heal without causing further trouble whilst others recur has been the subject of much speculation. Bankart maintains that it is because the nature of the lesion is different. He considers that in non-recurring dislocations the head of the humerus passes through a rent in the joint capsule which heals rapidly, whilst in recurring dislocations the glenoid ligament is detached and cannot re-adhere because of its poor vascularity. This view is disputed by many surgeons who think that the initial lesion is always a detachment of the glenoid ligament, and that when the dislocation recurs it is because the arm has not been immobilized for long enough to allow the injury to heal.

The pathology is of more than academic importance because, if Bankart's theory is accepted, it is unnecessary to immobilize the arm the first time the shoulder is dislocated; but if the other theory is correct, immobilization is essential. The safe practice is to immobilize the arm for

and not by the forearm, in order to keep the leverage small and reduce the risk of fracturing the humerus. The final movement is adduction and for this the scapula is fixed by hooking the fingers of one hand round its vertebral border.

OPERATION. It is not always easy to decide the best time to operate and as a rule it is necessary to await the response to conservative treatment. Operation should be considered when there is long-continued severe pain, and when the patient is prevented from following his usual occupation particularly if he is becoming mentally depressed. Sometimes operation is desirable when the symptoms are less severe. One of my patients had only a single symptom, pain at the extreme of external rotation, but his hobby was rock-climbing; manipulation was without effect and division of a single thread-like adhesion at open operation was successful. At the other extreme was a signalman who was incapacitated by a resistant bursitis due to a neglected
arthrodesis. The p
thickening of the l

Exploration of the Bursa is carried out through a 2 inch incision over the antero-lateral aspect of the shoulder. The fibres of the deltoid are separated and the roof of the bursa opened; the greater part of the musculo-tendinous cuff can be brought opposite the wound for examination by rotating the humerus. The operation proceeds according to the lesion found; calcified deposits may be removed, adhesions divided, and the bursa, or part of it, excised. The sheath covering the biceps tendon should be opened and if there are dense adhesions that are unlikely to resolve, the part of the tendon within the joint should be resected; the distal, free end of the tendon is attached to the shaft of the humerus, as is done when the tendon is ruptured (p. 359).

Excision of Acromion is reported as being a useful procedure in severe cases with thickening of the bursa, and even with complete rupture of the cuff, but the writer's experience of the operation has not been encouraging. The purpose of the operation is to remove the bony roof of the "bursa joint" which may be interfering with movement. The entire acromial process is excised through a "sabre-cut" incision and the deltoid muscle re-attached to the stump; the bursa and the outer portion of the coraco-acromial ligament should be removed at the same time.

Arthrodesis of the gleno-humeral joint is performed as a last resort in patients with incapacitating pain which has resisted all less radical treatment. The resulting disability is less than might be expected because scapulo-thoracic movement is not interfered with. The patient is able to get his hand to his mouth and to the back of his head, and to manage most kinds of work.

The best position in which to fix the shoulder in an adult is 60° of abduction in the scapular plane, and neutral rotation. The amount of rotation can be checked on the operating table by flexing the elbow — should bring the hand to the mouth. The joint is approached through a curved incision passing over the top of the shoulder and down the front

demands it. A sedentary worker who does not play games may not worry about a shoulder that goes out only every few years, but it is a real handicap to a house decorator or a tennis player. When operation is contra-indicated on general grounds, or refused by the patient, abduction can be restricted by an apparatus consisting of straps round the chest and arm joined by a link passing through the armhole of the coat.

Nearly a hundred operations or variations of operations for the cure of this condition have been described, but most have fallen into disuse. Those now most frequently performed for complete dislocation are Bankart's and Nicola's; for recurrent subluxation with a defect in the head of the humerus it is desirable to restrict external rotation permanently, and therefore a procedure of the Putti-Platt type may be preferable.

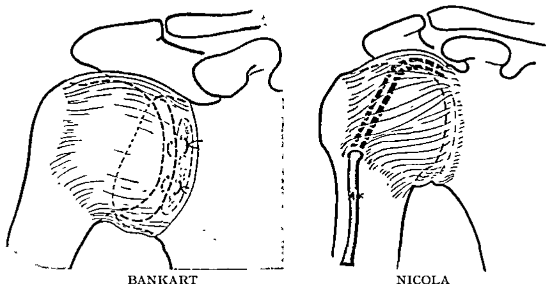


Fig 256 Operations for recurrent dislocation of the shoulder

Bankart's Operation is the only operation that restores the anatomy of the shoulder to normal and gives consistently good results and perfect function of the shoulder. It has not been adopted universally, perhaps because of its technical difficulty, but it is becoming the operation of choice of an increasing number of surgeons. Through an anterior incision the coracoid process is divided and reflected downwards together with the muscles attached to it, the subscapularis is divided and retracted inwards, the margin of the glenoid cavity is excoriated and the joint capsule is stitched to it (Fig. 256).

Nicola's Operation does not repair the defect but uses the tendon of the long head of the biceps as a check ligament. The results on the whole are good, but there is some permanent limitation of abduction, and subluxation may not be controlled, and in time the tendon may fray and rupture thus *permitting re-dislocation.* The upper end of the humerus is exposed through an anterior incision and a hole is drilled from near the edge of the articular cartilage to emerge in the bicipital groove about 1½ inches lower. The biceps tendon is divided, the proximal end is passed through the hole and the divided ends are sutured (Fig. 256).

three weeks after the initial dislocation in a young person. In older people the shoulder so often becomes stiff when immobilized that the comparatively small risk of the dislocation recurring may be accepted and early movements prescribed.

A defect in the postero-lateral aspect of the head of the humerus is demonstrable radiologically in many patients with recurrent dislocation, but not in all (Fig. 255). It is visible only in films taken whilst the shoulder is internally rotated about 60°, and since this is not a routine view in all departments of radiology, the incidence reported by different observers varies considerably. The cause of the defect is not fully understood, but the



FIG 255 Defect of the head of the humerus in a patient with recurrent dislocation of the shoulder.

importance is that, during external rotation and abduction, the defective part of the head comes opposite the antero-inferior margin of the glenoid cavity and allows the head to slip over it. Therefore, when a defect is present, dislocation takes place more easily.

Some patients sustain their initial dislocation without any greater violence than, say, bowling at cricket. It is probable that this occurs only when there is a defect of the head which is then able to slip over the margin of the glenoid whilst still remaining within the capsule. The injury is more in the nature of a subluxation than a true dislocation and the capsule is not necessarily torn or detached from the bone.

Treatment

Recurrent dislocation can only be dealt with satisfactorily by operation. Operation is indicated when dislocation recurs with sufficient frequency to be troublesome, and when the occupation of the patient

Acromio-Clavicular Dislocation

The integrity of the acromio-clavicular joint depends upon the coraco-clavicular and coraco-acromial ligaments and the joint cannot be completely dislocated unless both these ligaments are ruptured. Such an injury may be caused by a fall or a blow on the point of the shoulder. The clinical appearance is characteristic; the acromion is pulled downwards by the weight of the arm and there is an obvious step about half an inch deep at the site of the joint (Fig. 257). X-rays do not show the defect when

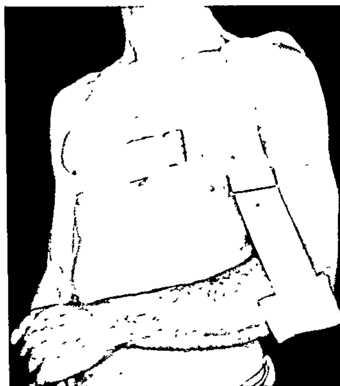


FIG 258 Webbing straps are a convenient method of supporting a dislocated acromio-clavicular joint The forearm is held by a "collar" and cuff "

taken with the patient lying unless the arm is pulled downwards. Subluxation occurs when there is only partial rupture of the ligaments and then the deformity, if any, is less obvious.

Treatment. CONSERVATIVE. At first there may be pain, swelling and bruising due to the ligamentous injury, but this soon subsides. The dislocation is readily reduced by raising the arm; it is difficult to hold the reduction and it is customary to attempt it by encircling shoulder and elbow with strips of adhesive strapping, but this stretches and a new layer has to be added every day or two. A simple and effective method of fixation is to use webbing straps arranged as shown in Fig. 258; the tension is increased as required by tightening the strap round the chest. Fixation has to be maintained for about six weeks during which time the joint must not be allowed to separate even momentarily. The ligaments reform reasonably well although they do not become sufficiently taut to prevent

PUTTI-PLATT OPERATION. The shoulder is approached anteriorly b severing the clavicular portion of the deltoid close to its origin, detachin the conjoined tendon of the coraco-brachialis and short head of the bicep from the coracoid process, and dividing the upper inch of the tendon c the pectoralis major; the subscapularis is cut one inch from its insertio and retracted medially. Repair is effected by fixing the short distal stum of the subscapularis in front of the joint, overlapping this with the proxim part of the capsule, and finally drawing the proximal end of the sul scapularis over everything and suturing it in the region of the great tuberosity of the humerus. This operation is successful in making th front of the joint secure and preventing re-dislocation, but abduction an external rotation are permanently restricted.

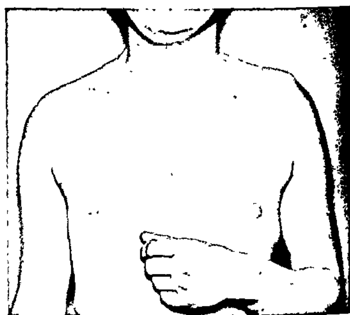


FIG. 257 Dislocation of the left acromio-clavicular joint There is an obvious "step" below the acromion

THE ACROMIO-CLAVICULAR JOINT

There is very little movement at this joint and when it is ankylosе there is no demonstrable change in the range of movement of the should girdle or of the gleno-humeral joint. The common disorders to which it liable are sprain, osteoarthritis and dislocation.

Sprains are the result of direct injury and occur with fair frequenc Osteoarthritis causing symptoms is less common than is often assumed bı typical changes can occasionally be demonstrated radiographically. Bot conditions can easily be confused with lesions of the musculo-tendinous cu because they may cause limitation of movement at the shoulder and pai referred down the arm. In acromio-clavicular lesions, however, tenderne is accurately localized to the joint and pain is caused by adduction of tl arm across the front of the chest. Treatment consists in physiotherapy an infiltration with novocain or hydrocortisone.

arm. In the absence of treatment the joint remains unstable and re-dislocation or partial re-dislocation occurs with any vigorous movement of the arm. The resulting disability interferes seriously with many occupations.

TREATMENT. If the clavicle is replaced immediately after the accident and is kept in position for some weeks, the torn ligaments are repaired and a good result may be expected. The method of fixation is to place a pad of wool in the axilla, carry the elbow well in front of the body and fasten it there with adhesive plaster; a thick pad of felt is then placed over the inner end of the clavicle and held with another strip of plaster to maintain downward pressure. Fixation is necessary for about six weeks.

Conservative treatment is useless for old-standing dislocations. If the symptoms warrant it, operative repair can be carried out by passing a suture of fascia lata through the clavicle and the back of the sternum. Alternatively, Jackson Burrows' method of using the tendon of the subclavius muscle for the same purpose may be tried. The joint capsule should also be tightened.

TUBERCULOUS DISEASE OF THE SHOULDER

The gleno-humeral joint is the least common of the large joints to be affected by tuberculous disease. Whitman gives the incidence in children as between one and two per cent of all cases of bone and joint tuberculosis. In adults involvement of the shoulder is relatively more frequent, but the total incidence is still small.

Clinical Features

The disease usually commences in the head of the humerus and soon spreads to the joint cavity. Two types are recognized.

(*a*) A DRY FORM (*caries sicca*) in which there is gradual destruction of bone by caseous infiltration. Pus formation is minimal and therefore abscesses and sinuses are unusual. The joint is fixed by spasm, and atrophy of the muscles round the shoulder is extreme.

(*b*) A FORMATIVE TYPE in which there is extensive formation of pus which distends the joint and makes the shoulder appear broader. An abscess frequently tracks forwards to point in front of the deltoid, and sinuses, often multiple, are common.

The typical symptoms of tuberculous disease—pain, deformity and restriction of movement—are less obvious at the shoulder because it is not a weight-bearing joint and because loss of movement at the gleno-humeral joint is masked by scapulo-thoracic movement. Tuberculosis should be suspected whenever there is gradually increasing stiffness of the shoulder accompanied by gross muscular wasting.

The onset as a rule is extremely gradual but deterioration is steady and without remission. Weakness of the arm and stiffness of the shoulder are often the first complaints. The absence of pain is a striking feature; many patients have no pain throughout the whole course and suffer at most a dull ache which is somewhat aggravated by excessive use of the arm. Only occasionally is the pain severe and sleep at night interfered with.

all deformity; the function of the arm is, however, excellent and the cosmetic result good.

Operative. Function, even with an untreated complete dislocation, is seldom greatly impaired and operation is not often necessary. It is, however, indicated occasionally in heavy manual workers or athletes on account of weakness.

There are two types of operation, arthrodesis of the acromio-clavicular joint and reconstitution of the acromio-clavicular ligament.

Arthrodesis. The acromio-clavicular joint is transfixed with three or four short lengths of Kirschner wire. The wires can be introduced through puncture wounds, or alternatively the joint may be exposed and the articular cartilage removed before inserting the wires. The cosmetic and functional results are said to be good.

Reconstitution of the Ligament. Several techniques have been evolved, as a rule using fascia lata passed around the corocoid process and through holes drilled in the clavicle. This type of operation restores the strength of the shoulder and diminishes, but never completely abolishes, the deformity.



Fig 259 Dislocation of the right sterno-clavicular joint

THE STERNO-CLAVICULAR JOINT

Ankylosis. Movement at this joint is essential for a full range of movements at the shoulder girdle. Ankylosis occasionally occurs as the result of rheumatoid or gonococcal arthritis and then the excursion of the scapula is somewhat reduced. The full range can be restored, should it be necessary, by excising a segment of the clavicle.

Dislocation. This is an uncommon accident which is usually caused by indirect violence forcing the inner end of the clavicle in front of the sternum. The dislocation often reduces itself spontaneously, but if this does not happen, reduction is readily affected by traction on the abducted

general treatment in an open-air hospital must be regarded as essential.

A full course of antibiotics is given (p. 129), and the shoulder is immobilised in the best position for ankylosis. A plaster spica is applied with the arm abducted in the scapular plane (Fig. 261). The angle between the axillary border of the scapula and the shaft of the humerus, which *must be checked radiologically, should be about 80° in young children,* decreasing to 35° in middle age. Rotation should be such that when the



FIG 261. A shoulder likely to become ankylosed should be immobilised in such a position that the hand will touch the mouth when the elbow is bent. An X-ray is necessary to check the scapulo-humeral angle (cf Fig. 250)

elbow is bent, the hand comes to the mouth. A window is cut in the cast to permit regular inspection of the joint. Healing is by fibrous ankylosis, or by bony *ankylosis if there has been secondary infection.*

Operation plays little part in the treatment of the active lesion, but when the disease is quiescent arthrodesis is usually desirable to give additional security. Arthrodesis should be performed by an extra-articular method; either the acromial process is bent downwards and its tip implanted into the greater tuberosity of the humerus, or Brittain's method may be used and a tibial graft introduced below the joint between the scapula and the humerus. Since the introduction of chemotherapy, intra-articular methods such as Charnley's are being used more frequently.

Examination in the dry form shows gross muscular wasting. The hollowness of the supraspinatus and infraspinatus fossæ is emphasized by the spine of the scapula projecting between them, and there is obvious flattening of the shoulder due to atrophy of the deltoid. Movement at the gleno-humeral joint is reduced or absent, and there is tenderness over every aspect of the joint including the axillary surface. When there is much pus formation the abscess may obscure wasting of the deltoid, but not wasting of the spinati.



FIG. 260 Tuberculosis of the shoulder originating in the metaphysis of the humerus.

X-rays (Fig. 260). The initial focus may be in the metaphysis or in the sub-chondral bone, but the infection soon invades the joint. The articular surfaces are destroyed and also a varying amount of the head of the humerus and the glenoid portion of the scapula. Sequestræ are common but there is seldom sclerosis or new bone formation. Decalcification of the neighbouring bone is usually extensive.

Diagnosis. Clinical diagnosis may be difficult, but a long history of disability with comparatively little pain, tenderness over the axillary surface of the joint, and extreme muscle wasting is very suggestive of tuberculous disease. An X-ray examination should always be included when investigating the cause of a stiff and painful shoulder.

Treatment

The prognosis is fairly good provided there are no other tuberculous lesions but unfortunately associated pulmonary disease is common and

local
and
epicondyle of the humerus (Fig. 262). During the acute phase there is sometimes diffuse tenderness over the extensor muscles. There is a full or nearly full range of active and passive movements but pain is caused by extending the elbow. The pain is usually increased by pronating the forearm and flexing the wrist whilst the elbow is extended, and occasionally by supinating the forearm and extending the wrist. In old-standing lesions the pain may spread over the whole of the back of the forearm and then the fascia is found to be thick and inflamed. The X-rays are generally negative.

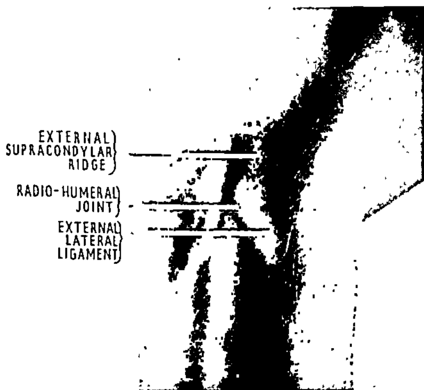


Fig 262 Outer side of right elbow to show the usual sites of tenderness in "tennis elbow"

Treatment. Injuries of this type do not respond to active treatment satisfactorily as most minor injuries and sprains. Some are very resistant, nd even when they have nearly recovered, the symptoms return when the m is used vigorously. There must be complete freedom from pain and nderness before it is safe to recommence strenuous occupations.

The earlier treatment is begun, the better the prospect of rapid cure. robably the best thing, if the patient is seen within a few days of onset, to apply an ordinary cock-up splint and place the extensor muscles at st for ten days or so. Unfortunately many people do not seek advice so uickly, and in any case they do not willingly accept the encumbrance of splint for so trivial a complaint. In these circumstances the elbow should e strapped with elastoplast applied over a sleeve of stockinet and xtending from above the elbow to the wrist. The hand is then used for all

CHAPTER VIII

THE ELBOW

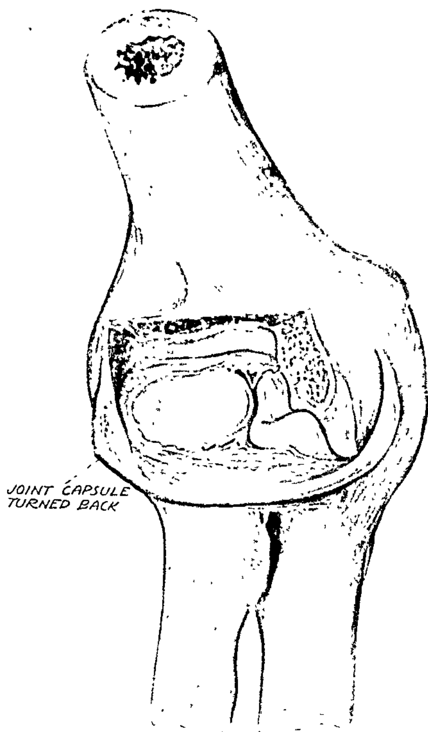
"TENNIS ELBOW"

This blunderbuss name is commonly applied to every disorder in which there is pain at the outer side of the elbow caused by energetic use of the arm. It resembles the term "low back pain" in that its use precludes any attempt to understand the pathology of the several lesions included. Only in a minority of patients is "tennis elbow" caused by playing tennis, and any occupation requiring a tight grip and rotary movements of the forearm may be responsible. It is certain that several distinct pathological conditions are included, and although they are not yet fully understood, it is a help in prescribing treatment to recognise two main types of lesion—extra-articular and intra-articular.

Extra-Articular

This is the common cause of pain at the elbow and yet there is little accurate knowledge of the pathology. Many different views have been advanced but none are properly substantiated, and it is unlikely that a single explanation will account for all cases. All that can be said with assurance is that there is a lesion of some kind affecting the extensor muscles of the forearm close to their origin at the outer side of the elbow, and that it is usually caused by a minor strain or by energetic use of the arms. It is notable that few of the muscle fibres are inserted directly into bone; most arise from ligaments, fascia and intermuscular septa which are relatively mobile and this makes it difficult to co-ordinate the contraction of individual fibres. Histological
nature of the lesion which could b
intermuscular fibrous tissue, or
metabolism.

Signs and Symptoms. There is a history of pain, usually of gradual onset, which the patient attributes to tennis or to an occupation involving much use of the forearm, such as clipping the garden hedge. The pain may not be noticed at the time but it comes on soon after, or perhaps next day. Sometimes the onset is abrupt and is associated with a particular incident, for example striking a piece of wood with a chopper. The pain is improved by rest but returns again on use; excessive use may cause widespread aching in the muscles of the forearm, particularly if gripping tightly is involved.



The Left Elbow.

Part of the lower end of the humerus has been removed to show the fold of the synovial membrane around the head of the radius

ordinary purposes, the elastoplast being renewed as often as is necessary t keep it firm. Recovery can be slow when treatment is delayed or the respons poor, but the strapping should be retained, and energetic use of the han avoided, for as long as the tenderness remains diffuse. Short wave dia thermy and massage may be helpful. Injection of novocain during th acute phase often does more harm than good.

At the chronic stage when the general inflammation has subsided an only a few localized tender spots remain, deep massage (or friction) is ofte successful in completing resolution. If that fails, or as an alternativ infiltration of the tender areas should be tried; novocain may be used bu hydrocortisone is probably better. Hydrocortisone has been claimed as panacea, but as far as is known at present, its use should be restricted t those occasions when there are only one, or a few, well localized tende areas.

Manipulation of the elbow with a general anæsthetic is of value whe there is restriction of movement accompanied by localized pain on forcin extension, presumably because there are intermuscular adhesions (Fig 263). Operation is occasionally desirable when all other methods hav failed. It should be carried out under local anæsthesia and without previou infiltration of the deep tissues; the tender spot is localized with the poin of a needle, novocain is injected and the area excised. Occasionally a smal adventitious bursa lying deep to the extensor muscles is found to be th cause of pain.

Intra-Articular

This type is uncommon but it includes a higher percentage caused by playing tennis. The pathology has been observed only during the late stages and the real nature of the process is a matter for conjecture, but th probability is that a fringe of synovial membrane is nipped between th articular surfaces of the radius and the humerus.

There is a delicate fringe of synovial membrane lying at the peripher of the radio-humeral joint, and usually quite a large tag posteriorly a the angle between the radius and the ulna (Plate IV). It seems that a fila ment of this fringe, as a rule the posterior tag, is displaced by an unguarded movement and becomes caught in the joint. Unless it is freed within a short time it becomes œdematous and eventually sloughs; a raw spot i left which may later adhere to another part of the synovial membran forming an adhesion. The raw spot is only a few millimetres in diamete and looks like a small urethral caruncle. The stages at which there is a raw spot or an adhesion have been observed at operation, but there i no positive evidence that the initial lesion is a nipped synovial fringe. I is only certain that there is some disorder of sudden onset which can ofte be relieved by manipulation and which, if neglected, develops the othe changes described.

Signs and Symptoms. There is a history of pain coming on suddenly during the pursuit of a characteristic occupation. The pain rapidly become worse and interferes with the use of the arm, and it may radiate down the

outer border and dorsum of the forearm. It is relieved by rest, but it returns when the arm is used again.

On examination there is tenderness accurately localized over the posterior aspect of the radio-humeral joint which is easily identified by a dimple (Fig. 262). Extension of the elbow and pronation are both slightly restricted and painful. Radiological examination is negative.

Treatment. At an early stage before the nipped synovial fringe has degenerated manipulation is usually successful. If carried out immediately after the onset, the result may be dramatic and the pain is instantly relieved; if, however, there has been time for an inflammatory reaction to develop in and around the fringe, it takes a few days for the symptoms to subside.



FIG 263. Manipulating the radio-humeral joint

Manipulation may also be successful at a late stage after an adhesion has formed. During the intermediate stage there is a raw area in the joint which has to heal, and manipulation is contra-indicated. The elbow should then be strapped and rested. The strapping should be applied with the elbow slightly flexed, and stretch from the middle of the upper arm to just above the wrist. Short-wave diathermy assists in promoting resolution. It is difficult to determine clinically the duration of this stage but it probably lasts for some weeks.

Manipulation during the early stage can be performed without an anæsthetic, but when adhesions are present an anæsthetic is desirable. The operator holds the elbow with one hand in such a way that his thumb rests on the back of the head of the radius; with the other hand he holds the patient's hand and moves the arm into a position of slight flexion of the elbow, full pronation and full flexion of the wrist (Fig. 263). The manipulative movement consists in extending the elbow whilst maintaining pronation and flexion of the wrist. The movement is made gently but quite sharply, and it is essential that the patient's muscles are relaxed. It causes no pain to a normal elbow but there is a sharp pain when a "tennis elbow" is freed. Another method of manipulation that is often successful is to open up the radio-humeral joint by adducting the elbow sharply.

Treatment. CONSERVATIVE. Heat and massage give some relief from symptoms provided energetic use of the arm can be avoided. When the pain is severe it may be necessary to provide an appliance to restrict movement of the elbow. A plaster cast can be used as a temporary measure, but for permanent wear a moulded leather or plastic splint is more convenient; the apparatus should extend from axilla to wrist, and if rotation has to be controlled the metacarpals must be included. An elbow hinge with a lock that will fix the joint at any desired angle is an added convenience (Fig. 265). No compressed air worker should continue at the same work after the first sign of trouble.

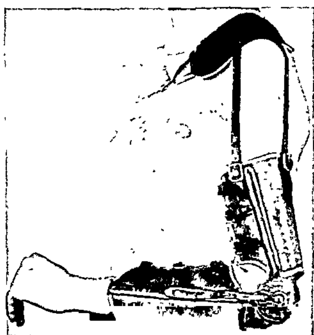


FIG. 265 Elbow corset with hinge and lock

OPERATION is necessary (a) for the removal of loose bodies, and (b) when there is much pain and disability which cannot otherwise be controlled, especially in young people.

Excision of the head of the radius is of value when symptoms are ---tricted to the radio-humeral or radio-ulnar joints.

Arthroplasty gives a more or less painless joint with a range of movents about 50 per cent of normal, but both stability and power are ısiderably reduced; the operation should only be performed when there nuch pain and some movement is essential (p. 444).

Arthrodesis is a good procedure when the affection is unilateral unless is of paramount importance to retain some movement. The best position arthrodesis varies with the occupation of the patient. The standard sition for the right arm is pronation 50 per cent and flexion about 100° permit writing and the use of a table knife; and for the left arm the me amount of pronation but flexion of rather less than a right-angle to able a fork to be put to the mouth.

OSTEOARTHRITIS

This is not a very common cause of disability because the elbow is not a weight-bearing joint, and there can be a surprising amount of disorganization without serious pain. Symptoms arise chiefly in connection with the radio-humeral joint through which pressure on the hand is transmitted, but the radio-ulnar joint is sometimes affected, and occasionally the humero-ulnar joint. Periarticular ossification, which is so common after dislocation of the elbow and other major injuries, must not be mistaken for osteoarthritis.

Osteoarthritis of the elbow is usually caused by trauma, either a malunited or ununited fracture, or frequently repeated minor traumata. Workers with compressed air drills are particularly liable to develop severe



Fig 264 Osteoarthritis of the right elbow of the captain of a steam tug whose occupation required him to turn a small wheel very quickly.

osteoarthritis of the radio-humeral joint. It seems that the repeated jarri causes interference with the blood supply of the bone and leads to extensi necrosis and absorption ; typical osteoarthritic changes are later supe imposed.

The symptoms are pain and limitation of movement. When the hea of the radius is involved, rotation is the movement chiefly affected. Pai is not constant and usually is felt only at the extreme of the permitte range of movement ; many patients are therefore able to remain at worl but some occupations may be impossible, especially those involving pressu on the hand or rotary movements. Locking of the joint due to the presenc of a loose body is sometimes the first symptom to attract attention.

at every stage. When consolidation is complete, movement may sometimes be increased by removing the mass of bone that is causing mechanical obstruction. Operation at an earlier stage is more likely to increase new bone formation than to reduce it.

OSTEOCHONDRITIS DISSECANS

This condition is probably identical with osteochondritis dissecans of the knee. The elbow is affected more frequently than any other joint except the knee, but because it is often difficult to demonstrate radiologically, the incidence is usually underestimated.

The pathology is described in detail on p. 219. The typical sites to be affected in the elbow are the lower aspect of the capitellum of the humerus, and that part of the head of the radius which is in contact with the ulna



FIG 267. Osteochondritis dissecans of the capitellum of the humerus

when the forearm is supinated. A small, circular area of articular cartilage together with a flake of the underlying bone separates from the rest of the bone and may become completely detached to form a loose body in the joint.

Osteochondritis dissecans of the elbow may be seen at any age between twelve and twenty-five years but usually between fifteen and eighteen. The onset of symptoms is gradual and there is seldom a history of trauma. There is a moderate amount of pain, limitation of movement, and loss of power. Locking may occur when the fragment is completely detached.

The diagnosis is made radiologically; the lesion can be difficult to demonstrate and a number of views at different angles may be necessary to show it in profile. A saucer shaped line of demarkation similar to that at the knee is seldom present, the more usual appearance being a rather ill-defined area of decalcification in the capitellum (Fig. 267).

Treatment. Osteochondritis of the capitellum of the humerus usually

PERIARTICULAR OSSIFICATION

Periarticular ossification is common after injury to any joint, pa ticularly the elbow. It occurs in a hæmatoma related to the injured bor As a rule, the periosteum is lifted from the bone and ossification occurs the hæmatoma formed beneath it. This may happen when the elbow dislocated, an injury which of necessity strips the capsule and periosteu from their attachments. Sometimes there is ossification when a fragment bone is avulsed, for example the upper pole of the patella, or the coronc process of the ulna. The new bone may then appear radiologically to invading muscle, and because of this, the condition has been describ erroneously as "myositis ossificans".

The new bone at first is *ill-defined and occupies* the whole space the hæmatoma, but as the blood clot contracts, it gradually becom smaller. In time the new bone consolidates and acquires an ordinary ca cellous structure.

to begin with, this i

that flexion and extension are nearly absent ; indeed, gross restriction



Fig 266 Periarticular ossification following a dislocation Consolidation of the new bone has commenced but is not complete.

movement after dislocation is a warning that *ossification* may be taki place. Movement increases as the new bone consolidates but there is oft some permanent limitation caused by mechanical obstruction.

Treatment. The most important step is prevention and therefore crêpe bandage should be applied after a dislocation or similar injury restrict the size of the hæmatoma. For the same reason avulsed fragme of bone, especially those with muscle attached, should be replaced position by operation. Ossification at the elbow is so common that t joint should be placed at rest in a plaster cast for two weeks after eve dislocation, even when there is no associated fracture.

Once new bone formation has begun the indication is rest, and t joint should be immobilized in plaster until X-rays show that consolidati is commencing. It is essential to avoid massage and · ve stretchi

at every stage. When consolidation is complete, movement may sometimes be increased by removing the mass of bone that is causing mechanical obstruction. Operation at an earlier stage is more likely to increase new bone formation than to reduce it.

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FIG. 267. *Osteochondritis dissecans of the capitellum of the humerus*

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Treatment. Osteochondritis of the capitellum of the humerus usuall

recovers with rest. The arm is fixed in a light plaster-of-Paris cast with t elbow at a right-angle and the forearm in neutral rotation. Fixation maintained until the X-rays show the fragment is becoming re-attache probably three to six months. If there is no improvement during this tin or if the fragment becomes completely detached, it should be excised.

Disease of the head of the radius is said not to respond as readily conservative treatment and therefore excision of the fragment is mo frequently practised.

LOOSE BODIES

Loose bodies in the elbow are common although they occur le frequently than in the knee; in the author's practice the proportion h been as one to two. A small loose body in the coronoid fossa is easi overlooked in radiographs unless stereoscopic films are available.



Fig 268 X-ray (printed in relief) showing two loose bodies in the front of the elbow joint

The pathology is in general similar to that of loose bodies in the kne (p. 218), but it is often difficult to determine the origin in a particula patient. Single loose bodies may be due to osteochondritis dissecans, whic is commoner than is often supposed, to osteoarthritis, or to a detached fragment of articular cartilage. Multiple loose bodies may be due to synovial osteochondromatosis.

The onset of symptoms is often gradual. There is increasing stiffness of the joint, loss of power and a moderate amount of pain after use. True

locking and unlocking are more frequent when the loose body is situated posteriorly in the olecranon fossa than when it is in front of the joint; it can be tucked away comfortably in the coronoid fossa to be disturbed only at rare intervals.

Treatment. A loose body causing symptoms should be removed because an elbow liable to lock suddenly is a source of danger, especially to a motorist. Access to the whole of the front and the outer part of the back of the joint is given by an incision in the line of the lateral supracondylar ridge of the humerus. The inner part of the back of the joint may be approached through an incision along the inner border of the triceps.

ULNAR PALSY

The ulnar nerve may be involved in injuries to the elbow either at the time of accident or soon after it (*primary palsy*), or after a long latent period (*delayed palsy*).

Primary Ulnar Palsy. This is uncommon. It is the result of contusion of the nerve (*neurapraxia*), and is usually associated with a fracture of the medial epicondyle of the humerus. On very rare occasions it is caused by compression of the nerve by callus. Spontaneous recovery is the rule.

Delayed Ulnar Palsy. Characteristically this develops a long time after injury, the latent period usually being at least ten years. As a rule the original injury is a fracture of the lateral condyle of the humerus which has either failed to unite, or has united with gross upward displacement of the fragment (Fig. 269). In both instances there is *valgus deformity* of the elbow which lengthens the path of the nerve causing it to be stretched round the internal epicondyle. It seems that the strain on the nerve causes irritation of its sheath; the sheath responds by becoming fibres. The reason for the long interval between the injury and the onset of symptoms is not understood but it has been noticed that symptoms often begin after unusually vigorous use of the elbow.



FIG 269 Ununited fracture sustained in childhood Ulnar palsy developed sixteen years later

Similar pathological changes occasionally occur some years after an injury to the nerve, such as a blow, and without fracture or deformity of the elbow.

Recurrent Dislocation. Occasionally the ulnar nerve dislocates over the medial epicondyle during movement and the same pathological changes

occur. The onset of symptoms is insidious and the condition may exist a considerable time without the patient being aware of it. The ætiol is usually unknown, but an injury is sometimes responsible.

Signs and Symptoms

The first complaints are usually numbness and tingling over the in border of the hand, pain at the inner side of the elbow on movement, a tenderness. Weakness and wasting of the small muscles of the hand suppl by the ulnar nerve develop slowly and progressively (i.e. the three musc of the hypothenar eminence, all the interossei, the third and fourth lu bricals and the adductor pollicis).



Fig 270 Clawed hand due to ulnar palsy.

The hand assumes the typical clawed appearance associated wi paralysis of the interosseous muscles, but the little finger and ri finger are affected to a greater extent than the others (Fig. 270). There ma be anæsthesia of the little finger and the ulnar half of the ring finger. Th nerve behind the medial epicondyle is usually very tender, and sometim it is obviously thickened. The differential diagnosis is given on p. 376.

Treatment

Conservative treatment is of little value and transposition of the ulna nerve to the front of the elbow is the procedure of choice. This usuall relieves pain and paræsthesiæ, and sensation often returns to normal. Th progress of muscle atrophy and of deformity are arrested ; there may be gradual improvement in muscle power but this is slow and rather uncertain Secondary changes of fibrotic nature take place in the fibres of muscle that have been denervated longer than about eighteen months and func tional recovery is then impossible. Operation must, therefore, be performed early.

The nerve is exposed through an incision at the inner side of the elbow, lifted away from its position behind the internal epicondyle and deeply embedded in the substance of the flexor muscles. Care must be taken not to injure the motor branches to the flexor carpi ulnaris and flexor digitorum profondus which are exposed.

Severe clawing may be corrected by transplantation of the flexor digitorum sublimis of one of the fingers to replace the interossei (p. 377).

RUPTURE OF BICEPS TENDON

This injury occurs during middle-age. The tendon of the long head of the biceps ruptures where it passes around the tuberosities of the humerus, or where it joins the belly of the muscle; occasionally the tendon of insertion is avulsed from its attachment to the radius.



Fig. 271 Rupture of the long head of biceps

The appearance with a rupture of the long head is characteristic. On flexing the elbow or supinating the forearm against resistance, the muscle fails to harden as it should and its bulge is lower in the arm than usual (Fig. 271). The symptoms are not as a rule serious. There may be a little pain at first, but it soon wears off. The loss of power is slight and interferes only with heavy work requiring strong supination.

With avulsion of the lower insertion, the muscle belly, although soft, remains at the proper level. The symptoms are rather more troublesome. There may be pain and bruising after the injury, and some permanent pain and weakness.

Treatment. Operation for rupture of the long head is necessary only when there is interference with function. No attempt is made to repair the tendon or to retrieve the proximal end which is loose in the joint. It is sufficient to anchor the distal end of the tendon to the humerus as high up as possible, or alternatively to attach it to the conjoined tendon of the coraco-brachialis and short head of the biceps. Avulsion of the lower insertion should be treated by re-attachment to the radius. The operation is not easy but the result can be excellent.

TUBERCULOUS DISEASE

The elbow is the commonest site in the upper limb to be affected tuberculous disease. The infection usually starts in the olecranon, and l frequently in the lower end of the humerus or the head of the radius. 1 disease frequently follows a slow and chronic course. The joint is invol early; it becomes distended with tuberculous material and the soft tiss around it are invaded. An abscess often points on one or other side of olecranon, and sinuses, once formed, are slow to heal.

The onset of symptoms is gradual but a sudden exacerbation may caused by a minor injury such as a fall on to the hand, or by vigorous of the arm. The first complaint is usually of pain and stiffness, but sor



FIG 272 Tuberculous disease of the elbow

times swelling or even tenderness are noticed earlier. Pain, except association with forced movement, is not a prominent feature.

On examination at an early stage there may be only slight limitati of movement, some muscle spasm, and possibly tenderness over t primary bony focus, usually the olecranon. Later, swelling becomes noti able and movement is increasingly restricted. The swelling is most obvic posteriorly on each side of the olecranon, and the joint stands out in mark contrast to the wasted muscles around it.

X-rays show the characteristic appearance of tuberculous disea There is loss of outline of the joint, destruction of bone and general decrea in density of the bones forming the joint. In adults an abscess cavi in the olecranon is often the most obvious radiological change (Fig. 27

Treatment. Conservative treatment in both children and adul gives a high percentage of successful results, but it is in 'tant for it to

carried out in an open-air hospital until the general condition is satisfactory and it is certain that there is no active pulmonary disease.

A full course of antibiotics is given and the joint is fixed in the best functional position (p. 129). A plaster-of-Paris or perspex cast extending from the axilla to the metacarpals is usually sufficient but a spica including the chest and shoulders may occasionally be desirable. Healing is by fibrous ankylosis and fixation should be continued for a considerable time after the disease is apparently quiescent. Operation is seldom required.

CHAPTER IX

THE WRIST AND HAND

TENOSYNOVITIS

ACUTE non-suppurative tenosynovitis is an apparently trivial condition but it has become common in these days of competitive production and is responsible for the loss of a considerable amount of working time. The tendons of the hand are affected more often than those of the foot, and nearly always the extensors.

Two regions are affected :

(*a*) the extensors of the fingers on the back of the hand, most often the extensors of the forefinger but any of the others may be involved alone or simultaneously.

(*b*) the musculo-tendinous junction in the lower part of the back of the forearm ; the muscles usually affected are the radial extensors of the wrist and the abductors of the thumb.

The pathological appearance, in so far as it affects the extensors of the fingers, has occasionally been seen at operation : the tendon sheath which should be smooth and glistening, contains small hæmorrhages, and the inner surface of the sheath is rough and red over a considerable area

There are four known causes :

1. *Repeated Rapid* [illegible]
as when squeezing a grip.
return to work after an absence, or when the speed of work has been increased.

2. *Trauma*, such as a blow over a tendon. There is immediate pain which gets worse during the next few days.

3. *Strain* due to overstretching may rupture a few fibres of the tendon

4. *Benign Tumours*. Sometimes a ganglion presses on a tendon and interferes with its free movement, and on rare occasions the cause is a small fibroma or a synovioma.

The chief symptom is pain felt in the region of the affected tendon, or in the lower part of the forearm, and often radiating widely. There may be visible swelling, and this is more obvious when the lesion is in the forearm There is tenderness on pressure over the painful region, and there is often crepitation which can be felt, and also heard on auscultation.

Treatment. Recovery takes place fairly quickly with rest, usually within about three weeks. The number of relapses, especially with lesions

at the musculo-tendinous junction, is large and in some circumstances is as much as fifty per cent. Strapping with elastoplast may be sufficient for mild lesions in those who do not work with their hands, provided the forearm and the affected finger or thumb are included. A plaster-of-Paris or perspex splint bandaged or strapped to the back of the forearm and hand is more satsifactory for manual workers and enables many to remain at work; it can be removed for short-wave diathermy if desired. Its use *should be continued until recovery is complete in order to reduce the risk* of a return of symptoms.

STENOSING TENOVAGINITIS

(*Synonyms*) de Quervain's disease, Hoffman's disease

This is a common complaint which has received but scant attention in text books although accounts of it were first published in the last century. The essential feature is thickening of the common sheath of the abductor pollicis longus and extensor pollicis brevis tendons where they lie on the outer side of the lower end of the radius. The thickening is fusiform in shape and 2 to 3 cms. long. Its greatest thickness is usually between 2 mm. and 3 mm., but in an extreme example it may be as much as 5 mm. Sometimes, although typical symptoms are present, there is only a trivial amount of thickening which cannot be felt.

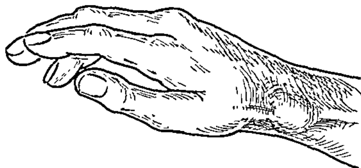


Fig 273 Stenosing tenovaginitis There is not always a visible swelling

The condition is more frequently seen in women than in men. The ætiology is unknown but it has been suggested that trauma is a factor because the complaint is often seen in people whose occupation involves strong *gripping* by the partly abducted thumb, for example, wringing the household washing. It frequently occurs, however, in those following more gentle pursuits when no such causal factor can be found.

The onset of symptoms is usually gradual. There is pain felt at the outer side of the wrist and radiating up the forearm and down the thumb. The pain is aggravated by the use of the hand and it gradually gets worse until ultimately it may cause considerable disability. Occasionally the onset of pain is abrupt and *follows a minor strain or injury.*

On examination, there is often a visible swelling on the outer side of the lower end of the radius (Fig. 273). There is tenderness on pressure, pain on active abduction of the thumb, and pain on forcing the hand into ulnar adduction whilst the wrist is flexed and the thumb opposed.

Treatment. Some amelioration of symptoms follows conservative treatment such as rest with the wrist fixed in a plaster-cast, but the pain returns when free use of the hand is re-commenced. Many patients have been treated conservatively for years without permanent relief, the diagnosis varying from arthritis to neuritis, and it is doubtful if recovery ever takes place without operation.

Operation is regularly followed by immediate relief from symptoms, and it should be advised whether or not there is palpable thickening of the tendon sheath. It is a simple procedure consisting only in making a longitudinal incision through the thickened portion of the sheath. When the sheath is greatly thickened a segment may be excised, but this is not often necessary. The arrangement of the tendons is very irregular and often one or more slips are enclosed in separate sheaths; care must be taken to free these aberrant tendons or it is likely that pain will persist. Active movements are commenced the day after operation and the patient can return to work in a few days.

TRIGGER FINGER

This is an affection in which free movement of the flexor tendons of one of the fingers or of the thumb is prevented by narrowing of the tendon sheath. It may occur at any age but chiefly in infancy and during middle life. The thumb is most frequently affected in infancy, and the middle finger or forefinger in adults. As a rule only one finger is affected but sometimes several fingers in both hands are involved. In infants, and occasionally in adults, the obstruction to movement may be in the synovia investment of the tendon, and unless this is looked for, operation may b unsuccessful.

The lesion, which is almost always at the level of the metacarpo phalangeal joint, consists in (*a*) a stricture of the tendon sheath, and (*b* a small nodule in the tendon distal to the stricture. As a rule the sheat is thickened in a manner closely resembling de Quervain's stenosin tenovaginitis, but sometimes there is only a local constriction of the sheat and no general thickening. The nodule forms within the tendon, usuall the profundus, as the result of it being "bunched up" by the milkin action of the stricture.

The affected finger can be flexed actively but whilst doing so a snap felt as the nodule in the tendon passes through the stricture, and a simil snap occurs during extension. Active extension is often impossible an the finger can only be straightened with the assistance of the other hand sometimes it cannot be straightened at all. On palpation over the met carpo-phalangeal joint, the nodule can be felt to move during acti flexion and extension of the finger.

Treatment. The treatment, which can be carried out at any ag consists in division of the stricture of the tendon sheath. This is followed b immediate and permanent relief. The incision through the skin should b transverse but the sheath is incised longitudinally on one of its later aspects, not centrally.

GANGLION

A ganglion is a cystic swelling occurring in association with a joint or tendon sheath. It has a fibrous outer coat, an inner synovial layer closely resembling the synovial membrane of a joint, and it contains thick, gelatinous fluid.

The ætiology of ganglia is still uncertain and no really satisfactory theory has yet been advanced. Some pathologists regard them as herniations of tendon sheaths or joints, but others consider them to be neoplasms developing by differention of the periarticular connective tissue, or as resulting from cystic degeneration of the same tissue. There is a close relationship between ganglia and bursæ and it is often impossible to draw a distinct dividing line between them.

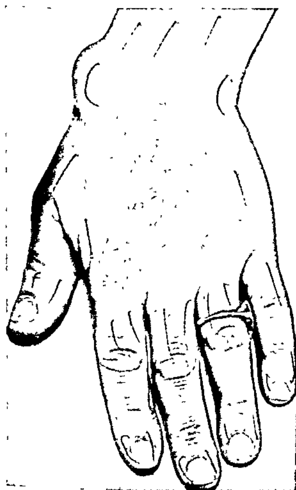


Fig 274 Ganglion (c f Fig 273)

Ganglia occur most frequently around the wrist and hand, and the ankle and foot. They are at least five times more common on the dorsal surface than on the ventral. As a rule they grow slowly, although sometimes they appear quite suddenly. The chief symptom is swelling (Fig. 274) but there may be some weakness of the grip and aching of the hand, and occasionally there is pain from pressure on adjacent tendons or nerves.

Differential diagnosis has to be made from epidermoid and mucous cysts, lipomata, neuromata, synoviomata, etc. A tense, spherical ganglion often found near the palmar surface of one of the metacarpo-phalangeal joints is frequently described after clinical examination as an exostosis.

Mucous cysts occur most frequently on the dorsum of a finger, usually in the mid-line and over the terminal phalanx. They vary in size up to about ½ inch and with the larger ones, the overlying skin becomes thin and attenuated. They are of importance, chiefly because simple removal is often followed by recurrence. They should be excised together with the overlying skin and a graft applied.

Treatment. Spontaneous disappearance without treatment is no uncommon. The simplest treatment is to burst the ganglion by firm digita pressure and disperse the fluid into the surrounding tissues. If it cannot b burst, it can be perforated by multiple punctures made with a needle an then dispersed by pressure. Recurrence is common but many gangli eventually disappear after being burst or punctured a number of times. [illegible]

Large ganglia, and [illegible] operation should be per[illegible] prepared for an extensive dissection amongst the tendons. [illegible] unusual provided th[illegible]

Aspiration and [illegible] but it is not uniformly successful; it is not without risk and often has [illegible] be repeated several times. Radiotherapy is credited with many successe[illegible]

SYNOVIOMA

These tumours are conveniently considered here because a majorit[illegible] occur around the hand and wrist. They are also found, but less often, [illegible] association with joints and tendons elsewhere, particularly the knee an[illegible] ankle. In the older literature they were often called after the predominatin[illegible] cell and named lipoma, xanthoma, endothelioma, chondroma, myeloma [illegible] giant celled tumour. It is likely that the more modern term "villonodula[illegible] synovitis" is also descriptive of a variety of synovioma.

Synoviomata are situated nearly always alongside a joint or tendo[illegible] and in the fingers it may be difficult to decide from which structure the[illegible] have originated. On the dorsum of the fingers and forearm, where they a[illegible] not uncommon, there is no synovial covering to the tendons. Ju[illegible] occasionally they occur at sites such as the inner side of the thigh where n[illegible] synovial tissue, not e[illegible]n a bursa, is normally present. But because of th[illegible] usual proximity of t[illegible] tumour to synovial tissue, and because the basic ce[illegible] is synovial, it is usually assumed that the origin must be synovial. E. S. [illegible] King has pointed out however, that they may equally well arise as th[illegible] result of differentation of non-specific connective tissue.

Most synoviomata are benign, a few are frankly malignant, and the[illegible] are many intermediate types. In benign tumours the typical cells a[illegible] spindle-shaped rather like fibroblasts, and the nuclei show but few mitot[illegible] figures. There are usually many large spheroidal cells which may conta[illegible]

droplets of fat (*foam cells*), and often they are multinucleate (*giant cells*). The presence of giant cells, which are of the ordinary foreign body variety, and foam cells, which are produced by ingested cholesterol, fatty debris, etc., is not essential to the diagnosis. Malignant tumours have a similar composition but the cells are irregular, the cell boundaries are poorly defined and there are many mitotic figures. A characteristic feature of both benign and malignant tumours is the presence within the tumour of spaces lined with synovial cells.

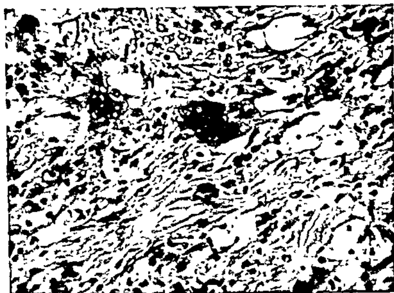


FIG 275 Microphotograph of a synovioma (by courtesy of Prof R W Scarff)

Clinical Features. Synoviomata are so diverse in character that a comprehensive account is impossible. Those arising in connection with the hand, and they form about three quarters of the total, are, however, fairly constant in their clinical behaviour. They occur during early middle age and are situated on any aspect of the fingers or thumb, usually close to a joint, or in the palm over a metacarpo-phalangeal joint. They are encapsulated and well defined, varying in size from a pin's head to an inch in diameter. The consistence is usually firm, but occasionally soft. The symptoms are chiefly mechanical, being caused by the size or position of the tumour, and it is often a couple of years before a doctor is consulted. This variety is almost invariably benign, and although local recurrence after excision is quite common, metastases are rare.

Tumours occurring in connection with the larger joints are sometimes pedunculated and lie within the joint; they resemble tumours of the hand closely and behave in the same way. Tumours around the large joints, and those occurring in connection with tendons in the forearm and leg, are relatively more often of an intermediate or malignant character. They may spread diffusely within the tendon sheaths; there is a variety occurring at the ankle which is readily mistaken for a lipoma but on dissection is found to involve all the tendon sheaths in the sole of the foot. It is of intermediate malignancy and spreads very widely, but without

infiltrating other structures; it does sometimes metastasize. Other types form a partly encapsulated mass which grows slowly, or sometimes very quickly, and occasionally it infiltrates and destroys the adjacent structures, including bone. Intermediate tumours of less malignant type tend to recur locally, but they metastasize late, or not at all. The frankly malignant tumours metastasize quickly, and even if amputation is performed early, they are usually fatal.

Treatment. Tumours of the fingers and hand, and pedunculated tumours, are usually benign and should be excised; when possible the portion of the synovial membrane or tendon sheath from which they seem to arise should be removed also. Sometimes, if the growth is large, amputation of a digit gives a better functional result. The histology should always be examined after removal. A recurrence can also be treated by local removal because, if the original tumour was truly benign, metastasis is highly improbable.

Tumours occurring elsewhere should be removed for histological examination or, if this is impracticable, a portion should be removed before the definitive treatment is decided. With tumours of low grade malignancy it may be desirable to accept the risk of possible dissemination even when they are so diffuse that complete removal is impossible. With the more malignant types, amputation offers the best chance.

RUPTURE OF TENDONS

Two tendons of the hand are liable to rupture spontaneously, or from trivial violence—the extensor pollicis longus and the extensor digitorum. The latter, when it gives way at the terminal interphalangeal joint, causes a "mallet finger," and when it ruptures at the proximal interphalangeal joint, it gives rise to a "button-hole deformity."

Extensor Pollicis Longus. "Spontaneous" rupture of the tendon of this muscle takes place where it lies in a groove on the back of the lower end of the radius. It often follows an injury to the bone at this site, as a rule after a latent period of several months, but it also occurs in old-standing rheumatoid arthritis. It is unusual after the typical comminuted Colles's fracture and is more often seen after a transverse fracture passing across the back of the radius. When rupture appears to follow a sprain of the wrist, radiological examination usually shows evidence of an old fracture. The tendon at the site of the fracture becomes frayed and attenuated, although why this should happen is not clear, and it is ruptured by some trifling violence. When the cause is rheumatoid arthritis the patient may not be aware of what has happened until he consults his doctor because of awkwardness in using the thumb.

The signs of the lesion are inability to extend the thumb actively at the interphalangeal joint, and absence of the tendon from its prominent position on the ulnar side of the "anatomical snuff box."

TREATMENT. Operation is desirable in younger people, but it is not necessary when the hands are already crippled by arthritis. End to end suture of the ruptured tendon is unsuccessful becau[illegible]'ts attenuated

condition and repair should be effected either by excising the pathological portion of the tendon and introducing a free graft, or else by suturing the distal end to the extensor pollicis brevis. Both methods give excellent functional results.

Mallet Finger. This deformity is caused by :—

(*a*) Avulsion of the extensor tendon from its insertion into the base of the terminal phalanx either with or without an attached fragment of bone. It is usually due to a blow on the tip of the finger flexing it forcibly at a moment when the extensor tendon is contracting, as when extending the hand to catch a ball (Fig. 276).

(*b*) Rupture of the tendon immediately proximal to its insertion. This is caused by inco-ordinated contraction of the muscles and may follow much smaller violence, or occur without any injury at all, as when a woman is slipping her hand into a stocking preparatory to putting it on.



Fig 276 Mallet finger with avulsion of a fragment of the distal phalanx



Fig 277 Position in which a mallet finger should be immobilized

The finger is held with about 70° of flexion at the terminal inter-halangeal joint (Fig. 300, p. 397). The joint cannot be extended actively ut there is normal passive movement. The flexed terminal phalanx is n inconvenience, and even when it does not interfere with work, it causes onstant annoyance by *catching in the trouser's pocket or handbag.*

Treatment by fixation of the finger in plaster-of-Paris gives an xcellent result provided this is done early and the plaster is applied orrectly. The terminal joint is extended to bring the fragments into ontact, and the proximal joint is flexed 90° to relax the lateral slips of the tendon. The plaster is not difficult to apply if the patient is first taught to hold the finger in this position himself, and then he can be responsible for its position whilst the plaster dries (Fig. 277).

The finger must be immobilized for four to six weeks. When the plaster is first removed the full range of active extension is not immediately present but it gradually returns during the next few months and the end result is usually perfect.

Old injuries are not satisfactorily treated by conservative methods. A good result can be obtained by re-attaching the tendon with a removable wire suture, but full function returns slowly and, as after the conservative treatment of early injuries, an early follow-up is misleading. Care must be taken not to injure the nail bed, which extends almost to the joint, or there will be permanent deformity of the nail.

"Button Hole" Deformity. This deformity is not caused by a longitudinal split in the extensor tendon, as is often suggested, but by rupture of the central slip of the tendon at the level of the proximal interphalangeal joint. It occasionally occurs as the result of violence, but more often from a cut with a knife (Fig. 278).



FIG. 278 "Button hole" deformity of the little finger. The proximal interphalangeal joint is flexed and the terminal joint hyper-extended.

The extensor tendon divides into three slips as it approaches proximal interphalangeal joint. The central slip is inserted into the mid phalanx and the lateral ones join together and pass to the terminal phala When the central slip is divided, the lateral slips are displaced towards palmar surface and flex the proximal interphalangeal joint; the termi joint and the metacarpo-phalangeal joint are extended.

Treatment. The central slip of tendon should be sutured, or attached to the phalanx with a removable wire suture. The results uncertain but the sooner operation is performed, the better is the progno Old injuries are particularly difficult to repair satisfactorily, and if attempt fails, function is improved by arthrodesing the joint in about of flexion. This can be effected by removing the articular cartilage a fastening the phalanges together by Charnley's met' ɔ).

SPRAIN

The Wrist

Sprain of the wrist is an uncommon accident, and when there appears to be a sprain it is usual to find that there is really a fracture, a dislocation or arthritis. X-rays in several planes, preferably stereoscopic, should always be taken when the wrist is injured. Fracture of the scaphoid is readily overlooked in films taken immediately after injury, and if pain and tenderness persist *for a fortnight, further radiological examination should* be made; the fracture seldom unites if left untreated, and although the symptoms may subside temporarily, osteoarthritic changes occur later. Avulsion of a flake of bone from the dorsum of one of the carpals, usually the triquetrum, is caused by a fall on the back of the hand when the wrist is palmar flexed; this should be suspected if there is tenderness over the dorsum of the carpus, and confirmation may be obtained by X-rays taken in a tangential plane.

Osteoarthritis of the radio-carpal joint often remains symptomless for a long time, especially *when caused by an ununited fracture of the scaphoid.* The onset of symptoms may be precipitated by injury and then the existence *of both the* arthritis and the fracture are *revealed radiologically.* Immobilization of the wrist in plaster-of-Paris for a month often relieves the pain and restores the wrist to the condition it was in before the accident.

Metacarpo-phalangeal Joints

Sprains occur from forcible lateral angulation or hyperextension. There is considerable *swelling, pain and disability and, like sprains of the inter-*phalangeal joints, recovery is slow. Recent injuries, when severe, should be immobilized for *two to four weeks* with the *hand in the position of rest* (Fig. 294, p. 392).

Rupture of the external lateral ligament of the thumb may be very troublesome. The thumb is unstable and weak, and on examination there is unnatural mobility. A complete rupture, if recent, unites with fixation in a plaster cast for a month, but an old injury may require repairing with a fascial graft.

Interphalangeal Joints

The delicate capsule and lateral ligaments of these slender joints are readily sprained or ruptured. *When the joint is dislocated, as not infre-*quently happens, the ligaments are either torn across or a fragment of bone is avulsed. Forced *hyperextension ruptures the anterior aspect of the* capsule and this may cause an intractible flexion contracture when it heals.

These injuries *are more serious than is generally admitted, even when* the ligaments are only sprained. They are often left untreated and the finger remains crippled for many months. The best procedure, immediately after injury, is to splint the finger in the position of rest for three weeks; even then, although function returns to normal, some fusiform swelling

The finger must be immobilized for four to six weeks. When the plaster is first removed the full range of active extension is not immediately present but it gradually returns during the next few months and the end result is usually perfect.

Old injuries are not satisfactorily treated by conservative methods. A good result can be obtained by re-attaching the tendon with a removable wire suture, but full function returns slowly and, as after the conservative treatment of early injuries, an early follow-up is misleading. Care must be taken not to injure the nail bed, which extends almost to the joint, or there will be permanent deformity of the nail.

"Button Hole" Deformity. This deformity is not caused by a longitudinal split in the extensor tendon, as is often suggested, but by rupture of the central slip of the tendon at the level of the proximal interphalangeal joint. It occasionally occurs as the result of violence, but more often from a cut with a knife (Fig. 278).



FIG 278 "Button hole" deformity of the little finger. The proximal interphalangeal joint is flexed and the terminal joint hyper-extended.

The extensor tendon divides into three slips as it approaches the proximal interphalangeal joint. The central slip is inserted into the middle phalanx and the lateral ones join together and pass to the terminal phalanx. When the central slip is divided, the lateral slips are displaced towards the palmar surface and flex the proximal interphalangeal joint; the terminal joint and the metacarpo-phalangeal joint are extended.

Treatment. The central slip of tendon should be sutured, or re-attached to the phalanx with a removable wire suture. The results are uncertain but the sooner operation is performed, the better is the prognosis. Old injuries are particularly difficult to repair satisfactorily, and if the attempt fails, function is improved by arthrodesing the joint in about 45° of flexion. This can be effected by removing the articular cartilage and fastening the phalanges together by Charnley's m 33).

nature, but the incidence in manual and clerical workers is identical.

Clinical Features. The condition occurs chiefly in middle-aged and elderly people, and occasionally in younger adults. Men are affected more frequently than women, and the right hand more often than the left, but sometimes it is bilateral. The ring finger is nearly always involved, and then the little finger, middle finger and forefinger in that order of frequency.

The first sign is a nodule which appears in the skin of the palm of the hand, or sometimes the first phalanx of the ring finger. The nodule increases gradually in size, other nodules appear and the skin becomes puckered (Fig. 279). The contracting fascia flexes the affected finger or fingers slowly and inexorably until, in an extreme case, the tips are pressed against the palm. The rate at which the deformity develops varies greatly and it may be a matter of months or of years before it is severe.

Examination shows the skin to be thick and nodular and adherent to the deep fascia. The affected fingers are flexed at the metacarpo-phalangeal and proximal interphalangeal joints, and extended at the terminal interphalangeal joints. Attempts to straighten the fingers make the palmar fascia more tense.

Treatment. A variety of conservative methods have been tried, including various sorts of injection, but none is effective. The best procedure is to excise the whole of the affected fascia. The operation is performed through transverse incisions in the creases of the palm, and when separating the skin from the thickened fascia, care is necessary to avoid cutting through the deeper layers of the skin and devitalizing it so that it sloughs. Since the skin is contracted and without its usual elasticity, there is often insufficient to cover the finger after it has been straightened. A skin graft can be applied, and this may be necessary with very severe deformities. In most cases, however, it is better to suture the skin with the finger partly flexed and then it will be found that the skin gradually stretches and extension returns over a period of months. Recurrence is unusual, at any rate for a long time, provided the dissection is sufficiently extensive. In a few patients, however, the process seems quite "malignant" and operation gives but a very temporary check.

ISCHÆMIC CONTRACTURE

(*Synonym*) Volkmann's Contracture

Temporary arterial occlusion in any limb, at any level and from any cause may produce irreversible changes in the muscles which die and subsequently are replaced by fibrous tissue. Volkmann originally postulated that the syndrome was caused by interruption of the arterial blood supply, but later it was attributed to venous occlusion. Recent experience, which is based on the operative findings of many surgeons, makes it clear that the old view is correct. A main arterial trunk is obstructed and this reduces the blood supply sufficiently to cause death of a few or many muscle fibres; the limited collateral circulation is sufficient to maintain the vitality of other structures.

The brachial artery is affected more often than any other, and the

of the joint may remain permanently. With oldstanding injuries, and many patients do not consult a doctor for some months, little can be done to speed recovery, but an assurance can be given that the pain will ultimately disappear, although some swelling may remain. Operation is necessary only in the exceptional instance when there is gross deformity.

DUPUYTREN'S CONTRACTURE

The palmar fascia lies immediately beneath the skin of the palm of the hand. The proximal border is attached to the transverse carpal ligament and receives the insertion of the palmaris longus muscle; distally it terminates in four bands of which some fibres are inserted into the skin just proximal to the webs of the fingers, and some pass to the four inner digits. It is joined to the deep fascia of the palm by longitudinal septa.



Fig 279 Dupuytren's contracture

In Dupuytren's contracture the palmar fascia is thickened and contracted, and one or more fingers are drawn into a position of flexion. The chief histological feature is fibroblastic proliferation; in some areas this proceeds very rapidly and the nuclei of many of the dividing cells contain mitotic figures. The fatty layers covering both surfaces of the fascia are infiltrated with fibrous tissue, and all the layers of the skin hypertrophy. The changes are not spread evenly over the hand but affect principally the ulnar side.

The ætiology is uncertain but heredity may be a factor because the contracture has often been observed in several generations of the same family. Trauma is sometimes blamed and there is often a history of a single injury, or of frequently repeated minor injuries of an occupational

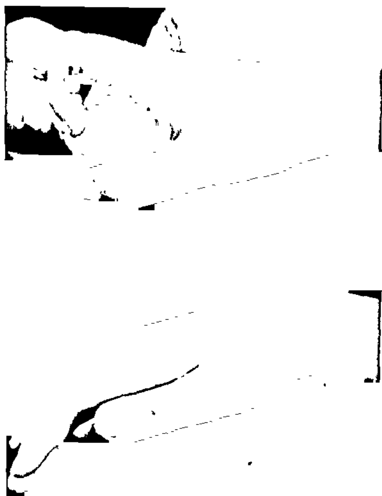


Fig 280 Established ischæmic contracture

Above : The wrist can be extended when the interphalangeal joints are flexed

Below : When the interphalangeal joints are extended, the wrist flexes



Fig 281 Extension for ischæmic contracture

upper limb more than the lower. The commonest cause is an injury of such a nature as to produce a contusion or laceration of the wall of the artery. This induces spasm and the spasm spreads both up and down the vessel involving its smaller branches, and sometimes even affecting the main branches at a much higher level, thus reducing the collateral circulation still more. The injury may be produced by a fragment of bone at the time of fracture, or it may be inflicted during the course of an operation, or occasionally it may result from a blow with a blunt instrument on the outer surface of the limb. Ischæmic contracture may also follow thrombosis or embolism involving an appropriate part of the artery. It does not, however, follow complete severance of a vessel because this does not cause spasm and the collateral circulation is not involved. It is most improbable that it can follow a tight plaster encasing the limb because this does not induce spasm, but a tight plaster may obstruct the circulation completely and cause gangrene.

Clinical Features. ACUTE PHASE. The first symptom is usually a burning pain commencing within a few hours of injury, but the onset of pain may be delayed for a day or two. When the forearm is affected, the fingers are held partly flexed and pain is caused by passive extension; there [illegible] the radial pulse is absent, and the sk [illegible]

It is not always appreciated that ischæmia can follow fracture of the femur, particularly in children. The femoral artery is injured and spasm spreads down to the posterior tibial artery. There is complaint of pain in the calf which becomes tender and swollen, and the pain is increased by passive dorsiflexion of the foot. The foot is usually blue, swollen and insensitive, and active movements are impaired.

CHRONIC PHASE. The dead muscle fibres are replaced by fibrous tissue which contracts and reduces the overall length of the muscle. The extent of the permanent damage depends on the amount of muscle destroyed; it may be slight and cause little impairment of function, or it may be great and a severe contracture results. In a typical example affecting the flexors of the hand and wrist, the fingers can be straightened only whilst the wrist is flexed, but when the wrist is straightened, the fingers are flexed (Fig. 280). Some power of active flexion of the fingers usually remains but it has little functional value because the wrist is flexed.

Treatment. ACUTE PHASE. Action must be taken immediately the possibility of arterial spasm is suspected—it must not be delayed for several hours "to see if there is any improvement". Positive indications are disappearance of the radial pulse, and excessive pain in the forearm on passively stretching the fingers. The first step, if the event has followed a fracture, is to remove any splints or bandages and see if the bones have moved. When this happens it is possible for a fragment to press on the brachial artery and arrest the radial pulse without causing spasm. If the pulse returns at once, nothing else need be done.

Failure of the pulse to return, is an indication for immediate operation. Conservative treatment is a waste of time, but if facilities for an arterio-

Local lesions of the ulnar nerve, which is rather exposed to cutting and perforating injuries, are amongst the commonest causes of claw hand. The ulnar nerve supplies the following muscles: the ulnar side of the flexor digitorum profondus, the abductor, opponens and short flexor of the little finger, all the interossei, the lumbricals of the ring and little fingers, the adductor pollicis and part of the flexor pollicis brevis. In ulnar nerve lesions, clawing is greatest in the little finger and rather less in the ring finger; the forefinger and middle finger are only slightly affected because the lumbricals, which are usually supplied by the median nerve, are strong enough to prevent gross deformity. Hyperextension is most marked in the little finger because the deep flexor is involved as well as the interossei and lumbricals (Fig. 270, p. 358).

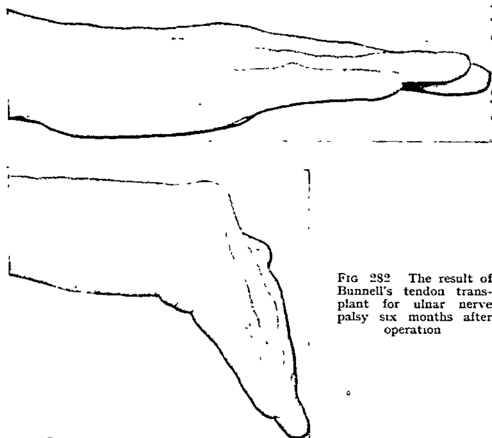


FIG 282 The result of Bunnell's tendon transplant for ulnar nerve palsy six months after operation

A clawed hand causes considerable inconvenience and is rather unsightly, but *Bunnell's operation* gives an excellent functional and cosmetic result although the finger from which the tendon is detached does hyperextend at the proximal interphalangeal joint (Fig. 282). The tendon of the flexor sublimis muscle is detached from its insertion into the middle phalanx of one finger, withdrawn into the palm, split longitudinally into two portions, re-routed along the lumbrical canals to two adjacent fingers and attached to the sides of the extensor expansions at the site of the insertion of the interossei. If it is necessary to deal with more fingers, a single flexor tendon can be split into three or four strands.

gram happen to be immediately available, this will give valuable information. At operation the vessel is exposed and the nature of the lesion discovered. Arterial spasm is often relieved within a few minutes by the direct application of a solution of papaverine to the wall of the vessel (injection into the circulation is without effect). If papaverine is not available, or fails to help, the adventitial layer, which contains the sympathetic plexus, may be removed from the affected part of the artery. Spasm has also been relieved on occasions by resection of the injured segment of the vessel.

ESTABLISHED CONTRACTURE. Contracture can to some extent be prevented, and mild and moderate contractures can be improved, by continuous traction. Extension should therefore be applied as soon as it is certain that there is muscle damage, and it should be maintained for several months. A usual method of exerting traction is shown in Fig. 281; the direction of the pull is such as just tends to extend the metacarpo-phalangeal joints. Traction is removed for a short time each day for active exercises.

Very severe contractures of the fingers, wrist and elbow, and fixed pronation of the forearm, are difficult to treat surgically. Many operations have been described, the most useful being *Max Pages's* muscle slide in which the common origin of the flexor muscles is detached and moved distally, and *Garré's operation* of shortening the radius and ulna thus increasing the relative length of the muscles.

CLAW HAND

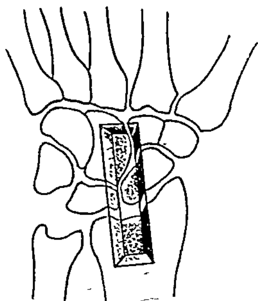
Claw hand is a [illegible]
interosseous and lum [illegible]
the interphalangeal joints and flex the metacarpo-phalangeal joints; when they are paralysed these movements are impossible and the fingers are drawn by the unopposed action of the long flexors and extensors into a position in which the interphalangeal joints are flexed and the metacarpo-phalangeal joints extended (Fig. 270, p. 358).

Wasting of the small muscles of the hand occurs in a formidable number of conditions of which examples are given below.

Spinal Cord.	Anterior poliomyelitis.
	Progressive muscular atrophy.
	Amyotrophic lateral sclerosis.
Nerve Roots.	Spondylosis.
	Leptomeningitis.
Brachial Plexus.	Obstetrical palsy.
	Pressure at the cervico-brachial junction.
Median and Ulnar Nerves.	Local lesions.
	Carpal tunnel pressure.
	Polyneuritis.
Muscles.	Dystrophies.
	Ischæmic contracture

circumstances. Excision of part, or the whole, of a fractured scaphoid or other carpal bone is equally unsuccessful. The most useful procedures are excision of the styloid process of the radius and arthrodesis of the wrist in moderate dorsiflexion.

Excision of the styloid process is a simple operation with a short convalescence (Fig. 285). Provided it is performed soon after the onset of symptoms, and before there are gross osteoarthritic changes, the results are good. The wrist, surprisingly, remains stable, pain is abolished or greatly reduced, and most patients are able to continue to work in light industry, and sometimes to remain at heavy work.



Above Fig. 284. Arthrodesis of the wrist



Right Fig. 285. Excision of the radial styloid.

Arthrodesis is a sure method of relieving pain; although it makes the wrist stiff, the grip remains good and almost any occupation can be followed, including that of heavy labourer. It is also of value for the painful wrist of rheumatoid arthritis.

A simple and satisfactory method of securing arthrodesis is as follows: a slot about half an inch wide is cut in the carpus and lower end of the radius (Fig. 284), and part of the articular cartilage is removed from the joints between the radius, scaphoid, lunate and capitate bones; a graft with the appropriate curve is cut from the outer table of the ilium to fit the slot, and the spaces between the carpal bones are packed with cancellous bone. Fusion is rapid; the splints, in most cases, can be removed in eight weeks, and full work resumed after three months.

OSTEOARTHRITIS

Radio-Carpal Joint

Osteoarthritis of the radio-carpal joint is common because of the frequency with which the joint surfaces are injured, but the mid-carpal and other joints of the wrist are less often affected. The commonest cause of radio-carpal osteoarthritis is an ununited fracture of the scaphoid; fracture of the lower end of the radius, even when the articular surface is involved, is less frequently followed by arthritis, but the reason for this is not known.

The symptoms are pain on using the wrist, limitation of movement and tenderness. The pain may be severe, interfering greatly with active use of the hand and preventing all but the lightest occupations.



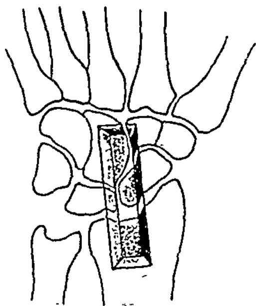
FIG. 283. Osteoarthritis of the wrist following fracture of the scaphoid.
Left Early changes two years after injury.
Right : Gross disorganization of the joint twelve years after injury.

The earliest radiological change is often an appearance of sharpness of the articular margin of the radius, and the styloid process is prolonged and pointed. Later, the joint space is narrowed and there are changes in the trabecular structure of the affected b[illegible] proliferation at the margins of the joint, [illegible] to be dignified by the term osteophyte (Fig. 283).

Treatment. The wrist is painful only when it is moved, therefore some relief is given by wearing a splint. Permanent splints are made of moulded leather or a plastic and should hold the wrist in about 30° of dorsiflexion. Few patients are prepared to wear a splint indefinitely and operation is usually preferred. Arthroplasty in my experience, leaves the wrist weak and rather painful and is worth while o[illegible] exceptional

circumstances. Excision of part, or the whole, of a fractured scaphoid or other carpal bone is equally unsuccessful. The most useful procedures are excision of the styloid process of the radius and arthrodesis of the wrist in moderate dorsiflexion.

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Above FIG 284 Arthrodesis of the wrist



Right FIG. 285 Excision of the radial styloid.

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Radio-Ulnar Joint

Disturbance of this joint is usually due to malunion of a fracture of the lower end of the radius. In a severe comminuted Colles's fracture the lower end of the radius is driven proximally thus dislocating the radio-ulnar joint, and unless the fracture is properly reduced the distorted joint may become a source of pain (Fig. 286).

The symptoms, which are not proportionate to the amount of distortion of the joint, are pain on pronation and supination of the forearm, tenderness on pressure over the radio-ulnar joint, and pain on passive antero-posterior movement of the joint.

Treatment. Excision of the head of the ulna is a satisfactory procedure which does not seriously interfere with the stability of the wrist. When this operation fails to relieve the pain it is usually because the source of the pain has been incorrectly determined.



Fig 286 Radio-ulnar dislocation resulting from a Colles's fracture



Fig 287 Osteoarthritis of the carpo-metacarpal joint of the thumb

Carpo-Metacarpal Joint of the Thumb

Osteoarthritis of this joint is a disabling cause of pain which seriously interferes with the use of the thumb, and therefore of the whole hand (Fig. 287). It may be caused by a malunited Bennett's fracture dislocation, or by repeated minor traumata sustained at work, but often no cause can be found. A clinical diagnosis can safely be made when there is tenderness

over the joint and pain on passive antero-posterior or lateral movement. The radiological changes are obvious when the disease is advanced, but a special technique is necessary to detect the earliest signs.

Treatment. A plastic splint encircling the hand and first metacarpal restricts movement of the joint and greatly reduces the pain. It is willingly accepted by many people, particularly by women who put it on for certan occupations, such as sewing, which otherwise are painful.

Arthroplasty of the carpo-metacarpal joint may be worth while in advanced cases but the results are not consistently good. The best method is to excise the trapezium but care must be taken not to cause unnecessary damage to surrounding structures or to leave fragments behind. Arthrodesis with the first metacarpal in a partly opposed position is occasionally necessary; this is effected by removing the articular cartilage from the joint and grafting a block of bone between first and second metacarpals.

KIENBOCH'S DISEASE

This is a puzzling affection in which the lunate bone becomes softened and deformed. The ætiology is doubtful and it is not even certain to which group of diseases it belongs. A similar condition occurs in the scaphoid, when it is known as *Preiser's disease*, and occasionally the other carpal bones are affected.

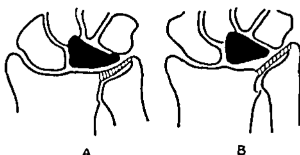


FIG 288 To show the relation of the lunate bone to the radio-ulnar joint (after Persson)
A In Kienboch's disease, and
B In a normal wrist

There is often a history of trauma but sometimes the violence is comparatively insignificant, and sometimes there is no known injury. Some surgeons regard the condition as a primary aseptic necrosis on which a pathological fracture is superimposed, others think there is a primary fracture, and yet others believe there is a low grade osteomyelitis. None of these theories explain fully the variable relationship with trauma. Hultén and Persson, however, have pointed out that the proximal surface of the radio-carpal joint is formed partly by the radius and partly by the triangular ligament, i.e. part is hard and part is soft. They claim that the relation of the lunate bone to the junction of the hard and soft surfaces varies, and that the disease has a marked predilection for wrists in which the centre of the lunate is opposite the junction (Fig. 288). They also advance histological evidence which suggests that necrosis of the bone is due to minute

crack fractures radiating through the spongy portion, and which may be caused by the lunate impinging on the corner of the radius.

Clinical Features. The condition is one of early adult life and rarely occurs before the age of fifteen years. Men are affected more frequently than women, and the right hand more often than the left.

Four stages can be distinguished :—

1. *Onset*, often following a known injury, with pain lasting for a week or two.
2. *A Period of Remission* for some months.
3. *Active Disease* with symptoms continuing for some years.
4. *Osteoarthritis* and permanent pain.

The pain is not severe at first but the wrist aches, especially during and after use. It becomes gradually more troublesome over a period of time and interferes with manual work. There is tenderness over the lunate, and pressure on the distal end of the third metacarpal causes pain.

X-Rays (Fig. 289). There may be symptoms before there is radiological evidence of disease. The first change is the appearance of patchy areas of rarefaction and increased density, and later the bone alters in shape becoming thinner and broader, and often wedge-shaped.



Fig. 289. Kienboch's disease in a sheet metal worker aged 29 years.

Treatment. The usual practice is to place the bone at rest unt the structure has returned to normal. The wrist is fixed in dorsiflexion in plaster cast and immobilization has usually to be continued for man months. When treatment is commenced early, resolution may take plac without great alteration in the shape of the bone ; but when it is delayec and this is usually the case, the bone is considerably distorted and ostec arthritic changes at the wrist joint are a common sequel. Treatment i then as for osteoarthritis (p. 378).

Excision of the lunate bone is sometimes practised when there is long standing pain, but few surgeons claim successful results. Arthrodesis is the only certain method of giving relief and restoring working capacity.

PYOGENIC INFECTION

The economic and social importance of infection of the hand is so great that no excuse is needed for emphasizing it. In this age of mechanization minor injuries occur with startling frequency both in the factory and the home, and only too often they lead to suppuration. Neglect of the injury and of the ensuing infection means weeks of suffering, but both the period of disablement and the residual disability can be greatly reduced by careful prophylaxis and proper treatment.

Treatment. Treatment of the ordinary infected finger is a simple business and perhaps for this very reason it is undertaken by almost every doctor, whether or not he is particularly interested in work of this sort. As was the case when fractures were first segregated and treated in special clinics, the segregation of infections of the hand for the purpose of treatment is followed by a striking reduction in both the period of disability and the number of complications. At one hospital, when hand infections were transferred from the casualty department to a special clinic, the period of disability was halved even though treatment was carried out by the same medical officers with only a little additional supervision. Another effect of establishing a special clinic is that it soon becomes known to the workers and housewives of the district and patients attend earlier in the course of the infection.

Prophylaxis. Many infections, but not all, can be prevented. Cuts and abrasions are satisfactorily cleansed by prolonged washing with soap and water, and this is much more effective than dabbing on an antiseptic. With pricking injuries the infecting bacteria are introduced deeply into the tissues *through a puncture wound at the time of injury* and proper cleansing is impossible. Prophylaxis must therefore be directed to preventing the injury, and much can be done by an observant factory medical officer working with a co-operative management. Care of the hands, particularly of the nails and cuticle, is of great importance and in some circumstances it is an economic proposition to provide women operatives with free manicure during working time! Once infection is established immediate treatment is essential and this should be impressed both on the workers themselves and on all those concerned with their medical care.

Operation. Operations for the release of pus or for the relief of tension should always be performed under general or regional anæsthesia, and in a bloodless field. "A stab at a whitlow with a quick gas" is a surgical crime—the anæsthetic must last long enough to permit a deliberate operation. A bloodless field is essential; it can be secured by a pneumatic tourniquet applied above the elbow, or by rubber tourniquet twisted, not tied, round the finger.

Penicillin is of undoubted value for the more severe infections and their complications. It is also probable that infection can be aborted if treated very early before there is pus formation and tissue necrosis, and it may help to localize the process once suppuration has commenced. *There is, however,* uncertainty as to whether the course of the ordinary established

paronychia or whitlow is shortened by penicillin, and the most important single factor in treatment is early and adequate drainage.

Clinical Types. The elaborate classifications sometimes used are simplified to six important types. They will not be discussed exhaustively and only the salient features of each will be indicated. The treatment recommended is well-tried and known to give good results if carried out with meticulous care. Other methods are under trial at a number of large clinics but orthodoxy is a wiser course for anyone with a limited experience.

1. Paronychia.
2. Whitlow.
3. Subcutaneous infection.
4. Palmar space infection.
5. Suppurative tenosynovitis.
6. Lymphangitis and cellulitis.

Paronychia

Infection is introduced beneath the cuticle (perionyx) as the resul of careless manicuring, or by a pin-prick, or from a "hangnail." The firs signs are pain, redness and swelling of the skin around the side and bas of the nail; later a bead of pus collects making a point of acute tendernes and finally the pus spreads around the base of the nail, and then beneatl the nail where it collects in the lunula. If left untreated, the nail-bed i partly destroyed and the nail permanently discoloured and deformed.

Some patients present a chronic infection which shows as a mass o granulation tissue at the base of the nail, or perhaps as a thin discharg from under the cuticle; treatment is as for an acute infection.

Treatment. Before the infection has spread beneath the nail it i sufficient to make an incision through the cuticle with the knife held hori zontally, a wide sweep being made from one angle of the nail to the othe (Fig. 290A). A tiny strip of a single thickness of tulle gras is placed in th incision to keep it open; it can usually be removed the next day and th wound should be healed three or four days later.

When there is infection beneath the nail wider drainage is essential and if there is any doubt it is better to err on the radical side. An incisio is made through the cuticle at the base of the nail as before, then th nail is cut transversely just distal to the lunula with sharp-pointed scissor and the base of the nail removed (Fig. 290B). A dressing of tulle gras i applied and the raw area epithelializes in about a fortnight; a new nai then grows and pushes off the remainder of the old one.

With the most severe infections cuts should also be made sloping back wards and slightly outwards from each angle of the nail, care being take not to injure the matrix, and a strip of tulle gras is placed beneath the flap to keep it open (Fig. 290c).

Whitlow

(*Synonym*) Felon

A whitlow is an acute infection of the pulp space on the front of th finger tip. The bacteria are usually introduced at the time of injury througl a puncture wound such as a pin-p

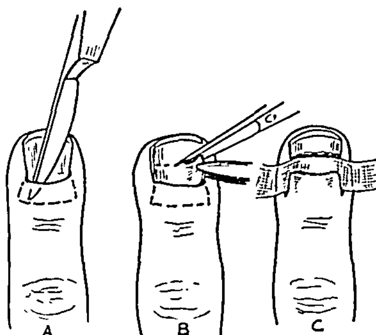


FIG 290 Incisions for paronychia

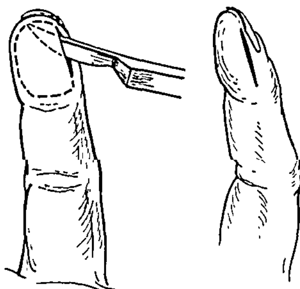


FIG 291 Incision for pulp space infection

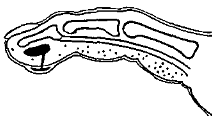


FIG 292 Subcuticular abscess communicating with the pulp space

day or two, the pulp becomes tense, swollen and indurated, the temperature is raised, and there is intense throbbing pain and exquisite tenderness. A small abscess forms after several days and then the pain becomes somewhat less. In the absence of early treatment the blood supply of the distal part of the terminal phalanx is cut off, the bone becomes infected and the finger and nail are permanently deformed. The abscess may also spread to the terminal interphalangeal joint and to the sheath of the flexor tendon.

A Subcuticular Abscess at the tip of the finger should be viewed with suspicion because it nearly always communicates by a sinus with a deep abscess in the pulp (Fig. 292). If the deep abscess is opened at once with the usual lateral incision, the tiny sinus will probably heal without a scar; but if it is not opened, the sinus enlarges and the resulting scar at the front of the finger is disfiguring and disabling.

Treatment. Rest is important whether treatment is begun early or late, and this is one of the reasons for applying a bulky dressing. A sling is desirable for two or three days, and if there is a severe infection, the patient should be put to bed with the arm elevated.

When there is no more than the slightest amount of pain and tenderness, it may be possible to control the infection with penicillin ; but as soon as an abscess has formed, or it is thought that one may have formed, or if the symptoms fail to improve, immediate operation is essential. Delay involves an unjustifiable risk, and if it should happen that no pus is found at operation, the surgeon should not be disappointed, but pleased that he has operated so early.

An abscess that is still subcutaneous and has healthy skin over it should be approached through a lateral incision. "Alligator mouth" and "hockey stick" incisions are unnecessary and they cause undesirable scarring which interferes with the tactile function of the finger tip. A lateral incision gives adequate drainage provided the knife sweeps right across the tip of the finger to the opposite side. The incision begins 1/10th inch from the nail and runs proximally, and very slightly towards the palmar surface, for a distance of ¾ to 1 inch. The knife is then swept across the pulp of the finger as shown in Fig. 291 ; the point should be palpable beneath the skin of the other side. Even when pus is encountered immediately below the skin incision, the complete operation must be performed in order to divide the longitudinal septa of the pulp space and ensure proper drainage. Great care must be taken not to injure either the bone or the distal end of the flexor sheath with the point of the knife or it may infect them. After operation a small wick of tulle gras is inserted to keep the wound open, it is removed after twenty-four to forty-eight hours and healing takes place in a few days.

An abscess that has perforated the skin, or is covered with dead, necrotic skin may be attacked by a direct approach. Dead skin is removed, or a sinus is excised with the smallest amount of surrounding skin. Sometimes it is possible to remove the entire abscess by dissection but this requires a most careful technique.

OSTEOMYELITIS. If a whitlow that has been opened properly fails to heal in a few days, or if there is extensive soft tissue necrosis when the finger is first seen, it is probable that the bone is infected. Radiological evidence of osteomyelitis does not appear for about a fortnight but administration of penicillin should be commenced as soon as the condition is suspected. The sensitivity of the infecting organism should be determined at the same time so that the appropriate antibiotic can be given without delay if there is no response to penicillin. X-rays are taken every four days, and if a sequestrum is shown, it should be removed. Rarefaction of bone increases during treatment with penicillin (p. 108) but this is not a sign of advancing infection, and no operation on bone should be performed unless there is definite evidence of sequestration.

Subcutaneous Infection

Infection of the subcutaneous tissues covering the proximal and middle phalanges is nearly as common as pulp space infection, but often slower to heal. Either the palmar or the dorsal surface of the finger may be affected, frequently as the result of a puncture wound, and there is a high incidence amongst fishmongers, kitchen boys and the like. Sometimes infection of the dorsal surface has more of the nature of a boil or carbuncle.

Patients come for advice rather later than when the pulp space is involved because there is less interference with function, and because the tissues are looser so that there is less tension and less pain. The usual signs of infection are present. Necrosis of the overlying skin is a common complication, but spread to the flexor tendon sheath and bone is less frequent.

Treatment. It may be possible, if the infection is seen at an early enough stage, to control it by chemotherapy, but an incision must be made as soon as it is suspected that pus is present. If the skin is intact, a lateral incision is made and a wick of tulle gras inserted. The incision must be placed far enough back to respect the neurovascular bundle, and particular care taken to avoid injuring the tendon sheath.

When the skin is necrotic, the whole of the dead tissues are carefully cut away and a separate incision is unnecessary. A skin graft applied to the raw area as soon as the infection has subsided both increases the rate of healing and reduces the amount of scarring.

Palmar Space Infection

The hand is divided by septa into a number of spaces containing loose areolar and fibrous tissue which is traversed by nerves, blood vessels, tendons and muscles. The spaces are named the web space, the mid-palmar space, the thenar, hypothenar and dorsal spaces, and the quadrilateral space of the forearm. Infection enters by puncture wounds, from cracks in the skin, and by extension from infected tendon sheaths. If neglected, it may spread to the tendon sheaths and joints.

The affected part of the hand gradually swells, the skin becoming

indurated, œdematous and thick; wooden hardness indicates that suppuration has commenced and pus is present. Movements of the fingers are restricted and painful when tendons or muscles pass through the infected space. Tenderness is accurately localized and this assists with the differential diagnosis from suppurative tenosynovitis.

Treatment. Infection, if treated *very early*, may be controlled by the administration of penicillin, but when an abscess has formed it should be drained without delay. The mid-palmar space is approached by the same incision as for the ulnar bursa, and the quadrilateral space as for the extension of the ulnar bursa into the forearm (Fig. 293). The thenar and hypothenar spaces are approached from the back of the hand but a palmar incision is sometimes required as well.

Web Space. This is the commonest type of fascial space infection. It often occurs in manual workers, the infection entering through cracks which form around callous and blisters on the palm of the hand. The web rapidly swells, at first in the front, and soon afterwards at the back of the hand. Although the pus collects chiefly in the palm, the abscess usually points dorsally; it tracks between the metacarpals which constrict it, hence the name "collar button" abscess.

Adequate drainage can usually be provided through a straight dorsal incision about one inch long between the metacarpal heads, but sometimes a palmar incision is required as well. The latter should be curved, as for the palmar extension in the exposure of a digital flexor sheath (Fig. 293).

Suppurative Tenosynovitis

Infection of a tendon sheath is one of the most serious affections of the hand and unless rapidly controlled it causes disastrous crippling. The infection is often introduced through a puncture wound in one of the creases in front of the finger where there is no subcutaneous fat, or by direct spread from a whitlow. It spreads very rapidly to involve the entire sheath including, in the case of the thumb and little finger, the radial or ulnar bursa. The sheath is distended with pus, the tendons lie in a pool of pus, their blood supply is cut off and they become necrotic. Later the sheath bursts and the fascial spaces of the palm are infected.

The affected finger or fingers are held stiff in a semi-flexed position and both active and passive movements are extremely painful. The area of the tendon sheath and its extension into the palm are exquisitely tender and can be accurately mapped out by gentle pressure with the point of a blunt pencil. The temperature is raised and other general signs of infection are present. After the sheath has burst movement is less painful; the hand, however, is more swollen and the dorsum becomes œdematous because the fascial spaces are then infected. When the ulnar bursa is involved all the fingers and also the wrist are held semi-flexed and stiff; the hollow of the palm disappears, there is swelling above the transverse carpal ligament and fluctuation may be detected.

Treatment. Antibiotics have greatly improved the prognosis, and if treatment is begun with the same urgency as after an abdominal catas-

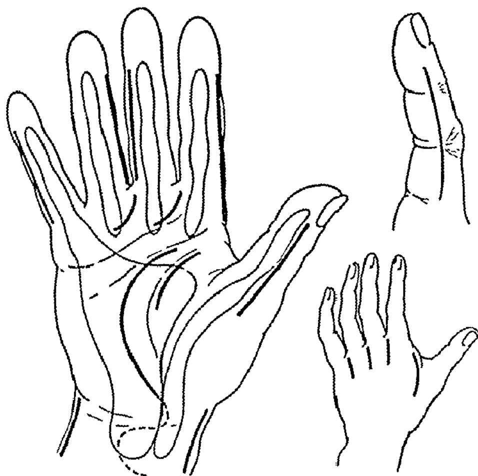


Fig 293 Incisions in the hand (modified from Bunnell)

trophe, there may be complete functional recovery. Systemic administration of penicillin is begun at once and continued until the sensitivity of the organism is known. In very early cases it may be unnecessary to make extensive incisions; the sheath is opened at each end and washed out with a solution of penicillin introduced through a fine polythene tube. When treatment is commenced later, the whole length of the sheath must be opened and, if it is involved, the corresponding palmar bursa.

The incisions are illustrated in Fig. 293. They are planned so as to avoid injuring the neuro-vascular bundles, and to avoid crossing the palmar flexor creases which leaves a painful and disfiguring scar. The finger and thumb are opened on one side only by an incision placed exactly between the volar and dorsal creases; this is just dorsal to the mid-point and therefore dorsal to the neuro-vascular bundle. When infections of the palmar and radial bursæ are treated late, incisions are necessary both in the palm and at the wrist proximal to the transverse carpal ligament.

Once a tendon has been deprived of its blood supply no chemotherapy can save it. A dead tendon looks grey and shaggy, and if left in the hand it acts as a foreign body and delays healing; therefore, as soon as its fate is beyond doubt, it should be removed. The wound can then heal with a minimum of fibrosis and a tendon transplant is possible at a later date.

Lymphangitis and Cellulitis

The hand is covered by a close network of lymphatic vessels and therefore infection by a virulent streptococcus that happens to find its host a favourable medium for growth spreads like a fire in a timber yard. The bacteria may enter through a cut or abrasion anywhere in the hand, often a puncture wound, and within a few hours the finger or the part of the hand concerned begins to swell and throb. There is usually a severe constitutional disturbance; the onset may be heralded by a rigor, especially if the blood stream is also infected, the temperature is very high and the patient soon becomes profoundly ill. The spread of infection up the arm is marked by red streaks which map out the lymphatic trunks; the lymphatic glands in front of the forearm and elbow and in the axilla become enlarged and tender.

The spread of infection may be so rapid and toxæmia so profound that the patient dies within forty-eight hours. On the other hand, in favourable circumstances and with early treatment, it may subside with equal speed. The typical infection, if untreated, follows a course between the two extremes and the forearm becomes indurated and brawny, finally breaking down with a diffuse liquefying cellulitis. The fascial spaces, tendon sheaths and joints of the hand are often involved, particularly when the infection starts in the palm. In less severe infections, the cellulitis is localized and subcutaneous abscesses form along the path of the lymphatics.

Treatment. The course and prognosis have been greatly modified by chemotherpay, and provided administration is begun within a few hours of onset, resolution may be expected without suppuration. When started later the spread of infection may be arrested, but even so convalescence is likely to be long and stormy. Incisions must not be made at the stage of lymphangitis because fresh tissue spaces are thereby opened to infection; pus should, however, be liberated when abscesses have formed whether in tissue spaces, tendon sheaths or joints.

TUBERCULOSIS

Tuberculous Tenosynovitis

Tuberculous tenosynovitis is a disease of adult life which affects the tendon sheaths of the hands more often than those of other parts of the body, and the flexors more often than the extensors. Infection of the right hand is more common than of the left, and many patients are artisans. These observations are sometimes quoted in support of the theory that the [illegible]

[illegible]

diseased meat certainly occurs at times, it is probable that, as is the case with joints, dissemination usually occurs via the blood stream from the mediastinal or thoracic lymphatic glands.

Pathology. The infection commences in the synovial sheath, usually in the palm of the hand. It is of low virulence and spreads slowly over a period of years until ultimately the radial and ulnar bursæ and their extensions into the forearm are involved (Fig. 293). The sheath is thickened and infiltrated with typical tuberculous granulation tissue which spreads around the enclosed tendons. At an early stage the bursal sac is distended by a straw-coloured effusion, but later the fluid becomes more viscous and contains "rice bodies" and "melon seed" bodies. These bodies are composed of fibrin deposited by the fluid exudate and rolled into concretions by the continuous movement of the tendons. Sometimes the sheath ruptures, setting the fibrinous bodies free in the palmar space. Large masses of firm caseous material involving all structures in the palm of the hand are occasionally formed.

The tendons lie in a bed of tuberculous material but are not usually invaded by it. After some time, however, they fragment and partially disintegrate, probably because their blood supply is interrupted. Even whilst the infection is progressing in some areas, healing by fibrosis takes place at others, and the tendons soon become bound together by a mass of fibrous tissue. The median nerve, owing to its position, is also surrounded by granulation tissue and this may cause pain and paræsthesia, but the power of conduction is seldom interfered with.

Signs and Symptoms. The onset is insidious and the history may extend over a number of years. The first complaint is of gradual swelling and stiffness of the fingers. Later the loss of power becomes marked, the fingers are held in a semi-flexed position and they cannot be fully flexed or extended. Finally, when the tendons become adherent, all movement is lost. There is seldom pain in the forearm or palm, but there may be numbness and tingling in the thumb and inner three fingers due to compression of the median nerve.

On examination, there is a swelling of doughy consistence in the palm of the hand and the forearm. The swelling is divided into two parts by the constriction of the transverse carpal ligament, and fluctuation between them can be demonstrated. Crepitus is sometimes felt on movement of the fingers but this is not a constant sign. The diagnostic features are impairment in function, swelling which varies from time to time and the absence of pain.

Diagnosis. There is a condition so closely resembling tuberculous tenosynovitis as to be distinguishable only by careful histological and bacteriological examination, and in my experience, it is commoner. The signs and symptoms are the same, but it progresses rather more slowly and the disability is usually less. The synovial sheath is thickened and convoluted and sometimes typical "melon seed" bodies are formed from the fibrinous exudate. The process is clearly inflammatory and histological examination shows chronic non-specific inflammatory changes without any of the ordinary appearances of tuberculosis. No organisms can be recovered by culture or by animal inoculation. The treatment, as for a tuberculous infection, is to remove the affected synovial sheath by dissection.

Treatment. CONSERVATIVE. The long term results of conservative treatment with antibiotics combined with rest are not yet known. Good results can be obtained sometimes by rest alone, and it is reasonable to expect that healing will be assisted, and recurrence made less common, by the addition of chemotherapy. It is desirable first to evacuate pus and fibrinous bodies. Small incisions are made above and below the carpal ligament and as much as possible is evacuated by pressure; the synovial sheath is then irrigated, and a solution of streptomycin is instilled before the wound is closed. A plaster cast is applied to the forearm and hand with the wrist dorsiflexed and the fingers in the position of rest. The back of the fingers should be left free to permit sufficient movement to prevent the tendons from becoming adherent.



FIG 294 The position of rest of the hand is that which it assumes naturally when the arm is hanging by the side

RADICAL EXCISION of the entire tuberculous mass probably remains the treatment of choice, if only because this makes it easier for antibiotics to reach the small amounts of tuberculous tissue that are not removed. A longitudinal incision is made in the mid-line of the forearm and curved across the wrist, and the transverse carpal ligament is divided to expose the whole tendon sheath. The sheath is then dissected away in its entirety taking meticulous care to preserve every nerve filament and small blood vessel. The hand is used as soon as the wound has healed and there is a rapid return of function if the damage caused by the disease is not too great.

Tuberculosis of the Carpus

Tuberculous arthritis affecting the wrist is infrequent at all ages but it is relatively more common in adults than in children. The pathological condition is the same as at other joints (p. 122), but because of the free communication between the synovial spaces, the infection spreads throughout the carpus and there is much destruction of bone.

In a typical case the classical symptoms of tuberculosis are present, that is pain, spasm and deformity. The wrist is held partly flexed, and the fingers are extended at the metacarpo-phalangeal joints and flexed at the interphalangeal joints. Wasting of the hand and swelling of the wrist are very obvious.

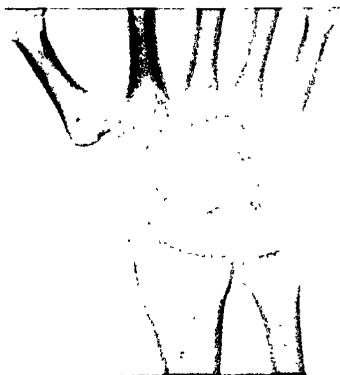


Fig 295 Tuberculous disease of the carpus

X-rays show the usual appearance of loss of outline, diminution of joint space, generalized rarefaction and the destruction of bone (Fig. 295).

Treatment. This is essentially conservative but it must be conducted in favourable general conditions. The prospect of recovery is greatly reduced if a patient in poor circumstances is permitted to remain on a meagre diet in an overcrowded home.

Antibiotics are given (p. 429), and the wrist is fixed in about 30° of dorsiflexion in a plaster cast. The cast should not extend beyond the proximal palmar crease in order to permit free movement of the fingers. If sinuses are present or threaten to form, the plaster is bivalved, or a metal splint is applied. When the disease is quiescent it may be desirable to give permanent protection by performing an arthrodesis (p. 379).

Tuberculous Dactylitis

The joints of the fingers rarely suffer from tuberculous arthritis, but the metacarpals and phalanges are occasionally the seat of tuberculous osteitis. Several bones may be affected at the same time and the condition is sometimes bilateral and symmetrical.

The infection commences in the medulla which is transformed into a mass of tuberculous granulation tissue. The cortex is eroded from within, and there is extensive subperiosteal bone formation. Ultimately the cortex is destroyed and the bone then appears to be greatly expanded (Fig. 296). The formation of small sequestræ is common, and often the skin is eroded leaving a sinus.



FIG 296 Tuberculous dactylitis (cf, Fig 231, p 304)

Treatment. Conservative treatment by fixation with the affected finger or fingers in the position of rest combined with chemotherapy (p. 429) is likely to be successful. If the integrity of the skin is threatened, the underlying bone should be exposed at operation and the infected tissues cleared out as thoroughly as possible. Amputation of the finger or excision of a metacarpal may be preferable when only one bone or a single digit is involved.

CONGENITAL DEFECTS

Congenital defects of the hands and the feet conform to a similar pattern, and therefore they will be described together.

It is known that nearly all types of defect are sometimes hereditary although sporadic cases also occur. Hereditary defects may recur in identical form in successive generations, but often only a tendency to malformation is transmitted and the exact form of the defect varies. It appears that the hereditary influence acts as a check to development at a critical stage, and the nature of the resulting deformity depends on the severity of the check and the embryonic stage at which it occurs (Bagg cit. Bunnell). Thus a check acting on the limb of a fœtus aged two and a half weeks may produce abrachius, at three weeks it causes polydactylism, and at six weeks syndactylism. Non-hereditary defects may be caused by a check to development of a different type, for example maternal rubella.

Congenital defects are numbered in countless variety, but certain of them recur with sufficient frequency to be grouped into types that can be named. A few illustrative types only will be mentioned briefly.

Radio-Ulnar Synostosis

This is a rare congenital defect in the development of the bones of the forearm. It is usually bilateral. Wilkie describes two types :—

1. The adjacent borders of the upper ends of the radius and ulna are fused for a distance of one or two inches. The head of the radius may be absent or joined to the ulna (Fig. 297).

2. There is in addition a congenital dislocation of the head of the radius, sometimes forwards but usually backwards. Fusion between the bones is at a slightly more distal point than in type 1.

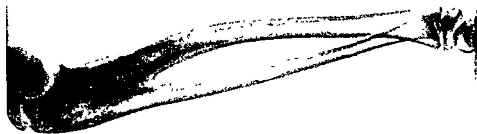


FIG 297 Radio-ulnar synostosis

In both types the forearm is pronated and the movements of pronation and supination are absent.

Operative treatment appears at first sight to be attractive but it is seldom successful because the soft tissues are involved in the developmental defect. The disability is less than might be expected because of the compensatory movements at the shoulder.

Congenital Absence of the Radius or Ulna

This is a rare defect but the resulting deformity is serious, and when bilateral it is most disabling. Other congenital defects of the hands and fingers are often present at the same time.

The radius may be entirely absent, or it may be represented by a small fragment at the upper or lower end; the ulna is short, curved, and thick, and the lower end articulates with the carpus. The hand is usually small, deviated to the radial side, and partly flexed.

Congenital absence of the ulna and congenital shortening of the ulna are comparable deformities, and rather more uncommon than absence of the radius (Fig. 299).

Treatment of both deformities is difficult because of the associated soft tissue defects. The wrist should be splinted from birth to reduce the deformity, and at two or three years of age it may be possible to correct it further by excision of contracted tissues, and by tenotomies. The bone is straightened by osteotomy and grafted, and finally it is fused to the carpus at a suitable angle.

Congenital Absence of the Tibia. This is the corresponding deformity in the lower limb and it is equally difficult to correct (Fig. 298). Even if the leg and foot can be straightened, the leg is so short that it is of less service than an artificial limb. Amputation is usually desirable and it may be performed at three or four years of age. The amputation should be of the Symes type and then an ordinary below-knee prosthesis adapted for an end-bearing stump can be fitted and the function is excellent.



FIG 298 Congenital absence of the tibia.



FIG 299 Congenital absence of the ulna (by courtesy of Mr P H Newman)

Clinodactylism

Lateral deflection of a finger or toe from the normal straight position is a common hereditary characteristic (Fig. 301). The little finger and forefinger are most frequently affected and usually they are bent at the level of the middle phalanx or the terminal interphalangeal joint towards the median axis of the hand. The deformity is not often severe enough to require correction but when necessary this can be done by osteotomy of the middle phalanx. This operation must be performed during early childhood.

Flexion of the little finger is another common familial defect (Fig. 300). The finger may be flexed as much as 90° but often the amount is smaller. In some people the deformity appears to increase during late adolescence or early adult life. Correction in adults is unsatisfactory because one or both the interphalangeal joints are deformed, and because the soft tissues

is simple and gives an excellent result. The distal end of the proximal phalangeal bone is divided and the finger splinted straight whilst it unites. The bone rapidly remodels during growth and becomes normal in shape.



FIG 300 Congenital flexion deformity of the little fingers (Note the mallet middle finger on the right hand.)

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Fig. 298 Congenital absence of the tibia



FIG. 299 Congenital absence of the ulna (by courtesy of Mr P H Newman)

Clinodactylism

Lateral deflection of a finger or toe from the normal straight position is a common hereditary characteristic (Fig. 301). The little finger and forefinger are most frequently affected and usually they are bent at the level of the middle phalanx or the terminal interphalangeal joint towards the median axis of the hand. The deformity is not often severe enough to require correction but when necessary this can be done by osteotomy of the middle phalanx. This operation must be performed during early childhood.

Flexion of the little finger is another common familial defect (Fig. 300). The finger may be flexed as much as 90° but often the amount is smaller. In some people the deformity appears to increase during late adolescence or early adult life. Correction in adults is unsatisfactory because one or both the interphalangeal joints are deformed, and because the soft tissues on the palmar surface are contracted. In young children the author's method is simple and gives an excellent result. The distal end of the proximal phalangeal bone is divided and the finger splinted straight whilst it unites. The bone rapidly remodels during growth and becomes normal in shape.



Syndactylism

Webbing of the fingers or toes is a congenital anomaly in which two or more digits are enclosed in the same sheath of skin (Fig. 301). The skin may pass directly from one finger to the next, or else it dips between them to make a thin web consisting only of two layers of skin. The web may extend to the tips of the fingers or terminate at any intermediate point.

Operation gives an excellent functional and cosmetic result but it should be postponed until about three years of age. It is essential to cover the bottom of the cleft with skin or else the scar contracts and draws down the skin of the hand to reform the web. Flaps of ample size to cover the cleft are cut first, and then dorsal and volar flaps are so fashioned as to cover as much of the fingers as possible; the raw areas remaining are covered with skin grafts (Fig. 302).



Fig 301 Web-fingers A bony ridge between the fingers, as shown here, is very uncommon Note also the lateral deflection of the little finger.

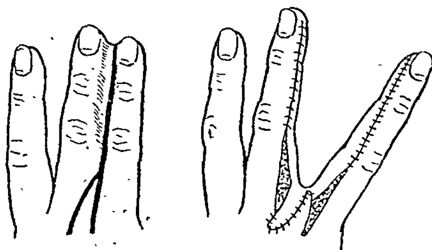


Fig. 302. Operation for web-fingers

Madelung's Deformity

Several deformities of the wrist are described under this name and are probably different stages in the evolution of the same defect (Moore):—

1. Forward subluxation of the wrist with laxity of the ligaments.

2. Forward subluxation of the wrist combined with posterior dislocation of the ulna.

3. *Increased curvature of the radius and dislocation of the ulna.* The lower epiphysis of the radius is oblique, and the ulna is relatively long and rests against the dorsum of the carpus.

The onset is nearly always during early adolescence and is accompanied by pain. Deformity develops gradually during the next few years. There is often, but not always, a history of trauma, and this is sometimes alleged to be the cause of the defect. Trauma does not, however, account for the uniformity of age at onset, nor the rarity of the condition. A more likely explanation is that there is a congenital disturbance in growth of the lower epiphysis of the radius (Fig. 303).

Adults with this deformity do not always have symptoms of sufficient severity to warrant operative interference, but operation is occasionally necessary for pain, or to improve the appearance of the wrist. With deformities of the first two stages, it may be sufficient to fasten the ulna in position by a sling of fascia passed round the neck of the bone and through the radius. With deformities of the final stage, the alignment of the wrist joint is corrected by osteotomy of the radius and the ulna is shortened.



Fig 303. Madelung's deformity.

"Lobster Claw" Hand and Foot

This congenital deformity is almost always hereditary although it happens that the boy illustrated in Fig. 304 was not known to have any similarly affected relatives. The function of such a hand can be remarkably good and serves for all but the finest work. When the cleft between the digits is poorly marked, function can be improved by deepening it. A "lobster claw" foot usually gives its possessor excellent service and causes but little disability.

A woman with such a hand, and whose sisters, mother and grandmother were all affected, was asked when she announced her engagement to be married, if she intended to have children. She replied that of course she did because she found her hands no disadvantage, nor did the other members of her family.



Fig 304 "Lobster claw" hand The function was improved by removing the two rudimentary metacarpals and deepening the cleft

Megalodactyly

Giant overgrowth may affect any one of the fingers, and sometimes more than one. The defect is not known to be hereditary and is different in nature from those already discussed because it is not caused by an arrest in development. The bones are enlarged in all dimensions and the soft tissues are hyperplastic. It is unusual for the metacarpals to be affected although in the example shown in Fig. 305 they are somewhat thickened.



Fig. 305 Megalodactyly

CHAPTER X

PYOGENIC INFECTION

OSTEOMYELITIS

Osteomyelitis is an inflammatory process resulting from the deposition and growth of micro-organisms in bone. The infection may reach the bone by three routes :—

1. By the blood stream, and occasionally the lymphatics, from a primary focus of infection elsewhere.
2. By direct spread from infected tissues in the vicinity.
3. From outside the body as the result of a wound.

The course varies with the mode of infection, the organism concerned and the resistance of the host. It may be acute, sub-acute or chronic.

Acute Osteomyelitis is usually the result of a blood-borne infection (acute hæmatogenous osteomyelitis). Direct infection through a wound seldom causes a virulent acute osteomyelitis for two reasons, firstly because the infection commences on the surface of the bone and therefore the deeper vessels are not obstructed in the same way as when it is blood-borne, and secondly because drainage is automatically provided at the time of injury.

Sub-acute Osteomyelitis may be due to a blood-borne infection by a micro-organism of comparatively low virulence, or it may be caused by the spread of infection from a neighbouring structure, or by direct infection through a wound.

Chronic Osteomyelitis may arise as a sequel to acute or sub-acute osteomyelitis, or the infection may be of such low virulence that the early stages are symptomless.

Pathology

All the constituent parts of the bone are involved and periostitis, osteitis and osteomyelitis cannot be regarded as separate entities. The ordinary pathological changes that accompany infection are modified when they occur in bone because of its structure and the arrangement of its blood supply. The following process, all or several of which may occur simultaneously, can be distinguished.

Necrosis. The smaller blood vessels are contained in rigid channels in the bone and the exudate produced during acute inflammation is unable to escape freely. The vessels are therefore compressed, the arterial supply and venous return are diminished or interrupted, and this leads to necrosis, or local death, of the parts of the bone affected.

Sequestrum Formation. Granulation tissue forms around the necrotic area of bone and gradually separates it from the living bone. A sequestrum

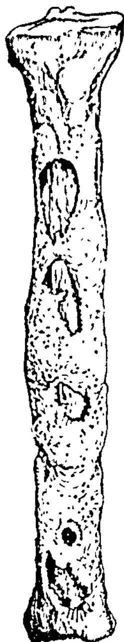


FIG 306 Chronic osteomyelitis of the tibia (From the Hunterian collection of the Royal College of Surgeons of England)



FIG 307 Chronic osteomyelitis of the ulna showing a massive sequestrum and great thickening of the bone

is seldom absorbed in the presence of infection, and healing cannot take place until the sequestrum has been discharged spontaneously or removed surgically.

OSTEOPOROSIS (*caries*) occurs when the bone is eroded and replaced by granulation tissue. This process is more typical of the granulomata (e g. tuberculosis) than of pyogenic infection although it often occurs in the latter.

[illegible] ..rounding an inflammatory zone is an almost [illegible] during the stage of healing. New bone is deposited in the cancellous spaces making it more dense.

PERIOSTEAL BONE FORMATION varies considerably in amount; it is usually extensive when the periosteum is stripped up by an abscess or is separated by a layer of granulations from necrotic bone. When there has been massive death of bone forming a large sequestrum the whole area becomes surrounded by new periosteal bone which is then known as the *involucrum*. The involucrum is perforated by *cloacæ* through which the discharge can escape (Fig. 306).

ACUTE HÆMATOGENOUS OSTEOMYELITIS

This is a condition in which infection in bone occurs during the course of a generalized disease—bacteræmia, septicæmia or pyæmia. It is essentially a complaint of childhood usually occurring before the age of ten years, and in at least 90 per cent of cases before growth of the long bones has ceased. Males are affected more frequently than females in the proportion of about three to one. The disease involves children living in the poorest conditions more frequently than those of well-to-do parents and the incidence is decreasing, perhaps because of improvement in the general standards of hygiene and cleanliness.

Pathology

The infecting organism is a staphylococcus aureus in about 80 per cent of all cases and a streptococcus in 10 per cent. In infants under three years of age, however, streptococcal infection is commoner than staphylococcal, and although the initial attack is more virulent and the mortality greater, there is generally less destruction of bone and the sequelæ are less serious. Infection by almost every other known micro-organism has been reported, and simultaneous infection by two or more is not unknown.

The commonest sites of infection in order of frequency are the upper end of the tibia, the lower end of the femur, the humerus, the fibula and the radius. Every other bone including the skull, mandible, vertebræ, carpal and tarsal bones are occasionally involved.

The infecting bacilli are carried in the blood stream from a primary focus elsewhere in the body, perhaps a boil, pimple or other minor lesion of the skin, or perhaps an infection of the naso-pharynx. The initial bony focus is usually in the metaphysis of a long bone (i.e. the cancellous bone adjacent to the epiphysial disc), and occasionally in the epiphysis, in the medulla or under the periosteum. The reason for the frequency with which the metaphysis is affected is not certain, but it has a particularly good blood supply and the channels containing the capillary vessels are narrow; this both slows up the rate of flow of the blood and reduces the space available for mobilization of the local defences. Minor trauma causing capillary hæmorrhage in the bone is often said to be a predisposing cause but its importance is uncertain.

When the infection has gained a hold in the metaphysis a small abscess is formed. As the abscess grows, tension develops and the pus tracks in the directions of least resistance, that is centrally to the medullary cavity, and outwards along the epiphysial disc to the subperiosteal region (Fig. 308).

The periosteum is stripped up and a subperiosteal abscess is formed which rapidly encircles the bone and eventually breaks through into the soft tissues. The adjacent joint is seldom involved although occasionally it is infected by direct spread through the epiphysis, or indirectly from the soft tissues. Direct spread to the joint is rare in children, except at the hip, because of the barrier formed by the epiphysial disc.

Necrosis of bone occurs to an extent depending on the stage at which treatment is instituted and how widely the infection has spread; it varies from a negligible amount up to death of almost the entire diaphysis.

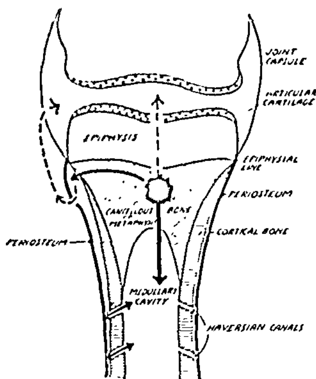


FIG 308 Methods of spread of acute hæmatogenous osteomyelitis at the upper end of the tibia.

Clinical Features

There is sometimes but not always a history of injury. The first complaint is usually of pain and tenderness near a joint which increases rapidly in intensity; jarring is painful and small children refuse to use the limb at all. Constitutional signs of general infection precede or immediately follow the onset of *local symptoms; the child is obviously ill*, the face is flushed, the tongue furred, the pulse rapid and the temperature raised to 103° or 104°.

On examination there is tenderness to pressure which is localized to the immediate neighbourhood of an epiphysial disc. It is important to [illegible] ness is over the bone, not the joint, and care [illegible] point. The joint can usually be moved gently [illegible] *causing pain* provided the weight of the limb [illegible] and extension are nearly always painful. At an early stage there is little or no swelling but later the overlying soft

tissues become red, swollen and œdematous. There may be an effusion into the joint even though it is not infected.

There is usually a polymorphonuclear leucocytosis of 15,000 to 30,000; absence of a satisfactory white cell reaction gravely affects the prognosis. In staphylococcal infections the staphylococcal titre is raised. Blood culture is frequently positive.

Diagnosis. The clinical findings of pain and tenderness at an epiphysis in a child that is ill are sufficient evidence to call for immediate treatment. Soft tissue swelling and œdema are late signs and to wait for their appearance may cause irreparable damage to the bone. X-rays show no change in the structure of the bone until at least ten days after the onset of symptoms.

Occasionally there is pain in several bones for the first day or so and then the condition resembles acute rheumatism. A pyogenic infection, however, usually localizes rapidly to one bone and this, together with tenderness over a metaphysis and the hæmatological findings, should make the diagnosis clear. When there is any doubt treatment as for acute osteomyelitis should be commenced at once.

Acute suppurative arthritis may be simulated when acute osteomyelitis is accompanied by a serous effusion into the joint. The aspirated fluid is, however, clear on naked eye examination, whereas it is cloudy or frankly purulent in arthritis.

Course and Treatment

Antibiotics have revolutionized the treatment of both septicæmia and acute osteomyelitis. Septicæmia, except in fulminating cases, can be controlled, the course of the infection in bone greatly shortened, the subsequent morbidity reduced and the overall mortality, formerly in the region of 20 per cent, has been reduced to less than 1 per cent. Provided administration is commenced early it is probable that the bone will return to normal, and even if treatment is delayed, rapid control of the infection may still be possible. Surgery is often unnecessary, and in many cases the most that is required is to aspirate an abscess or provide drainage by a simple incision.

In accordance with the usual principles for the treatment of acute infection, immobilization is desirable. The part must, however, remain open for inspection and therefore a bivalved plaster is used for infection near the knee, a Thomas's splint with weight extension for the upper end of the femur, and an abduction splint for the humerus.

An antibiotic must be given at the earliest possible moment. It is far better to terminate the attack before there is any damage to bone, even if an occasional unnecessary injection is given, than it is to wait until the diagnosis can be confirmed and perhaps serious damage has occurred. The organism is usually sensitive to penicillin and this should be given in large quantities, say 300,000 units every six hours. If a favourable response is delayed for longer than 36 hours some other antibiotic should be added, and if pus becomes available for examination, the sensitivity must be

determined at once. Administration should continue for at least a week after the constitutional and local signs of infection have subsided.

The course depends on the virulence of the infection, the resistance of the patient, and the stage at which treatment is begun. There are two clinical types depending on whether the picture is dominated by the infection in bone or by the general infection.

(*a*) *Localizing Type*. This is the usual form. The infection is rapidly localized to a single focus in bone, and although the patient may be seriously ill, the bone infection is of chief importance.

(*b*) *Fulminating Type*. The general infection completely overshadows the local condition in bone which may easily be overlooked.

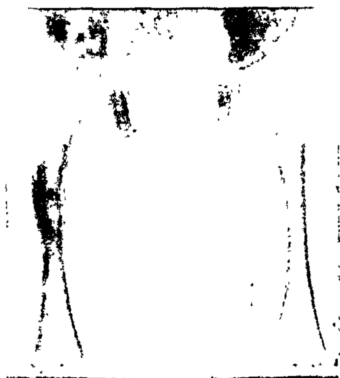


FIG. 309. Acute osteomyelitis of the femur in a baby aged three weeks. Penicillin was given 20 hours after onset. X-ray four weeks later

Localizing Type. The course is determined more by the time of commencing administration of penicillin than by any other factor. On this basis three groups can be distinguished. They are not sharply defined and serve only as a guide; treatment must depend on the particular circumstances, and when there is doubt it is better to operate early than to wait until the damage has increased.

1. TREATMENT COMMENCED EARLY, within a day or two of onset. The general signs begin to go within two or at most three days and the temperature returns to normal within a week; the local condition subsides as rapidly and no soft tissue abscess is formed. No surgery is required. The limb returns quickly to normal and there is no fear of recurrence.

X-rays may show no changes at any stage, but sometimes after a fortnight there is a little necrosis of bone and some periosteal reaction (Fig. 309).

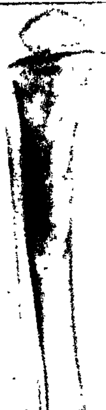
2. Treatment Commenced Later, two or three days after onset. The infection takes rather longer to control and it is several days before the general symptoms begin to subside. A soft tissue abscess forms which may remain subperiosteal or break through and become subcutaneous. A small abscess can be treated by aspiration but this is attended by greater risks than operation. A safer practice is to make an incision as soon as it is suspected that there is pus beneath the periosteum and evacuate the abscess. It may also be desirable to make a few holes in the metaphysis with a drill to ensure free drainage. The wound usually heals quickly but weight-bearing should be delayed until the extent of the damage to the bone is known.

X-rays of these patients show an interesting series of changes. After about ten days, subperiosteal new bone is laid down and the affected part of the metaphysis commences to undergo patchy decalcification giving the bone a somewhat mottled appearance. Decalcification increases for some weeks and then the bone returns gradually to normal. It is evident that penicillin, by destroying the infection, converts a process of septic necrosis into one of aseptic necrosis. Areas of bone which were killed during the acute stage, instead of separating and becoming sequestræ as would have happened had they remained septic, are gradually revascularized and ultimately they are reconstituted as normal bone (Fig. 310).

3. Treatment Commenced Late, after several days (Fig. 311). The course is not unlike that before penicillin was discovered because the infected areas have no blood supply and the drug is unable to reach them. There is much local destruction of bone and extensive soft tissue abscesses are formed. The general toxæmia, however, is more readily controlled, fewer sequestræ are formed, and healing is quicker. Soft tissue abscesses should be evacuated by incision as soon as possible, and the metaphysis, and sometimes also the medulla, opened widely enough to provide free drainage. Healing may occur within a few weeks but complete control of the infection may not then be obtained and the condition degenerates into one of chronic osteomyelitis. The dead bone separates as sequestræ; new bone is deposited under the periosteum (involucrum), and in the healthy bone surrounding the infected area (sclerosis); discharging sinuses may persist indefinitely (Figs. 306 and 307).

Secondary infection of a joint, usually the knee, occurs occasionally and is satisfactorily treated by aspiration of the fluid and replacement with penicillin. The penicillin should be given without waiting for the result of bacteriological examination if the naked-eye appearance of the fluid is suggestive of infection (p. 419).

X-rays show extensive destruction of bone, sequestrum formation and deposits of new subperiosteal bone. When the infecting bacteria have all been destroyed, the normal reaction of sclerosis around an infected area does not take place. Cases have been recorded in which revascularization of sequestræ occurred, and it has been suggested that the sequestræ, having become sterile, are treated by the body similarly to autogenous bone grafts.



20th January.



26th February.

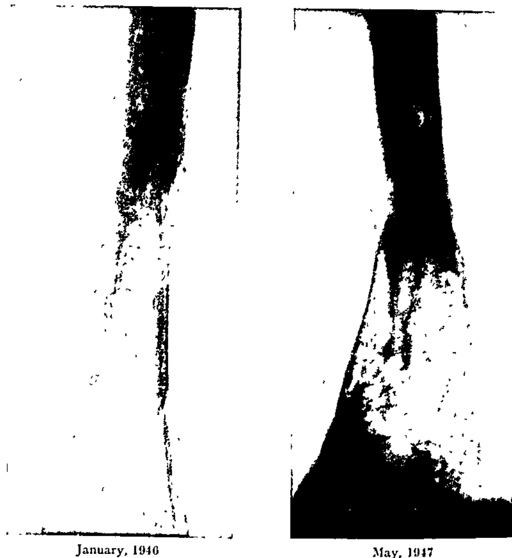


23rd April.



5th August.

FIG. 310. Acute *osteomyelitis of the tibia.* Onset 3rd January, penicillin given 40 hours later. The *infection subsided quickly* but the X-rays showed *aseptic necrosis followed by gradual reconstitution* of the bone.



January, 1946 — May, 1947

FIG. 311 Osteomyelitis of the lower end of the femur of a girl aged eight years Treatment was not commenced until three weeks after the onset Massive sequestra were removed four months later (January, 1946) and then the sinuses healed rapidly

Fulminating Type. The majority of fatal cases are of this type. The condition is primarily a septicæmia and osteomyelitis is but an incident in its course. Blood culture is always positive; Butler has shown that a colony count is of prognostic value, and when it is of the order of 500 to 1,000 per c.c. the prognosis is grave.

The patient becomes profoundly ill within a few hours of onset and the general condition deteriorates rapidly. There are often multiple embolic abscesses of which only some are in bone. Death may occur in twenty-four or forty-eight hours before there is time for penicillin to exert its effect.

The treatment is mainly that of the general condition. Very large quantities of penicillin should be given, say 500,000 units four-hourly until there is a sign of improvement. Body fluids must be maintained by parenteral administration of saline, etc. A localized abscess in bone may be drained if the general condition permits.

Typhoid Osteomyelitis

Acute infection of bone by B. typhosus or paratyphosus is an occasional complication of enteric fever occurring in less than 1 per cent of cases. The lesion is most frequently subperiosteal and affects the shaft of a long bone or the body of a vertebra, but any bone may be involved. The onset is usually during the convalescent stage of the fever; the temperature rises, the affected bone becomes painful and tender, and the overlying soft tissues and skin may show signs of inflammation. The amount of pus formed is small. On rare occasions an abscess becomes encapsulated in the bone and causes symptoms many years later.

Resolution often takes place without operation. The part is placed at rest and watched carefully; if definite suppuration occurs, the abscess should be incised, the pus evacuated and the cavity swabbed out. A chronic abscess is dealt with in the same way as a Brodie's abscess.

CHRONIC OSTEOMYELITIS

Chronic infection of bone may be the result of incomplete resolution of an acute blood-borne infection, or it may be the sequel of a penetrating wound. Occasionally a blood-borne infection is subacute and the stage of necrosis and new bone formation is reached without an initial acute illness. Infection following gunshot or other penetrating wounds is often of a comparatively low-grade character from the start.

The pathological condition is essentially one in which there are infected cavities surrounded by sclerosed bone. The cavities may be single or multiple, of any size or shape, and they may communicate with each other and with the surface of the body by sinuses; they are filled with infected granulation tissue and may contain sequestræ. The involucrum, if present, often grows to a considerable thickness; it has a rough, pitted surface and is perforated by cloacæ that permit the discharge of pus (Fig. 306). The bone and sinuses become surrounded by masses of dense fibrous tissue in which bacteria may be encapsulated.

The X-ray appearances vary with the cause and extent of the disease. A sequestrum is usually more opaque than the surrounding bone and has clearly defined margins. Massive sequestræ often retain a more or less normal structure and may show division into cortical and cancellous bone. The reason for the apparent increase in density of sequestræ is not always clear. Sometimes it is due to the surrounding bone becoming decalcified whilst the sequestrum, which has no blood supply, retains its normal composition. This explanation is not satisfactory in all instances, and there is some evidence that sequestræ undergo an actual increase in density. After healing the bone seldom returns completely to normal and some radiological evidence of past disease remains permanently.

Course and Treatment

Established chronic osteomyelitis, whether due to an unresolved acute blood-borne infection or to a penetrating wound, follows a similar course

and requires similar treatment. The treatment of recent osteomyelitis caused by penetrating wounds is outside the scope of this book.

Penicillin has not the same dramatic effect as in acute infections and once an infection of bone has become chronic, it may remain a trial to the patient (and the surgeon) throughout his life. Sequestræ are without blood supply, and there is but a poor blood supply to the masses of dense fibrous tissue which surround the bone, and which replace the soft tissues destroyed by the original injury and the subsequent suppuration; drugs applied locally or administered parenterally are therefore unable to reach the infecting bacteria.

Chronic osteomyelitis may pursue one of three courses (Perkins).

1. The inflammation becomes quiescent but recurs at intervals of months or years without causing sinuses.
2. The inflammation becomes quiescent leaving a sinus extending to the interior of the bone and remains permanently in this condition.
3. There is a persistent sinus as in 2, and also recurring attacks of subacute inflammation.

1. Recurrent Flares without Sinuses. The original wound heals but the bone does not regain its normal radiological appearance. There are often areas of rarefaction and sclerosis but sequestræ are seldom present (Fig. 312). There is usually much fibrosis around the bone and extending into old cavities, and recurrence is as often due to infection remaining dormant in fibrous tissue as in bone. The patient may remain symptom free and lead a normal life for months or years, but sooner or later the infection flares up—some men wounded in the 1914-1918 war had their first recurrence as long as twenty-five years afterwards.

The recurring infection starts as an ache in the bone which gradually increases in intensity and may become really bad. There is some malaise and the temperature is raised, but toxæmia is not severe. There is local swelling and tenderness, and the skin may become red and œdematous.

TREATMENT. Attacks can generally be controlled by chemotherapy. The response to penicillin should first be ascertained; if this is unsatisfactory it may be worth while making a small opening in the bone to get some pus and determine the sensitivity of the infecting organisms. A soft tissue abscess should, of course, be aspirated. Rest is necessary for all but the slightest cases, preferably in bed, and the limb should be splinted. Extensive operation on the bone should be avoided because they invalid the patient for a long time and seldom prevent further recurrences.

2. Persistent Sinuses without Flares. Some acute infections subside leaving one or more sinuses which remain indefinitely but cause no more trouble than is involved in an occasional dressing. Often there is only enough discharge just to stain the dressing, and sometimes the sinus scabs over and only discharges occasionally. The surrounding skin remains fairly healthy.

A sinus indicates the presence of a sequestrum, a retained foreign body or a continued low grade infection of bone and soft tissues. It is important to decide which because a sequestrum or foreign body can be removed,



Left Fig. 312 Chronic osteomyelitis of the humerus with no sinus but frequent flares Several operations had been performed without lasting effect

Above Fig 313 Chronic osteomyelitis of the ulna following a gun shot wound A sinus was present and healed rapidly after removal of the sequestrum

but it is improbable that an infection of bone or soft tissues can be eradicated completely. X-rays are helpful, but not decisive; they show some sequestræ but not all, and they show metallic foreign bodies but not retained bits of clothing (Fig. 313). The presence of a foreign body is not conclusive proof that it is causing the trouble.

Treatment. Sinuses are very hard to cure and conservative treatment, including the administration of both local and parenteral antibiotics, is usually without effect. Operation is only occasionally successful, and even if the wound does ultimately heal, subsequent flares are very common. The patient may be suffering comparatively little inconvenience and a decision to operate should not be made lightly. It may be justifiable to make one search for a foreign body or sequestrum, even if none is shown

radiologically. Extensive procedures of the type described below are more likely to convert a tolerable into an intolerable condition than to cure the patient.

3. Persistent Sinuses with Flares. These are a perpetual source of trouble. There is an infection of bone that is continually active and every now and then, perhaps every few months, it flares up. The discharge may be considerable and is very irritant, causing much trouble with the skin.

TREATMENT. The repeated attacks of inflammation are physically and economically incapacitating and a serious attempt should be made to eradicate the diseased tissues. Minor operations are seldom worth while, and they take nearly as much of the pateient's time.



FIG 314 Brodie s abscesses in the lower end of the femur and the upper end of the tibia which remained symptomless for nineteen years

Good skin cover is essential and the first step is to excise unhealthy scars; it may be possible to bring the edges of the skin together but often, particularly when the tibia is involved, a graft is necessary. At the definitive operation all scar tissue outside the bone and within it is excised. The bone is opened widely and every bit of infected and unhealthy bone removed, and sclerotic bone surrounding cavities is cut away until healthy bone is exposed—sometimes half or more of the circumference of the shaft has to be removed. Bone grafts should be avoided when possible, but if a cavity remains which cannot be filled with soft tissues, chips of cancellous bone from the ilium may be used.

Brodie's Abscess

which occurs when the the patient are nearly npanied by acute illness and usually passes unnoticed. A small abscess is formed in the bone and it is rapidly encapsulated and walled in by a ring of dense, sclerosed bone. Such abscesses occur most commonly in the metaphyses of the long bones near the epiphysial discs. As growth proceeds the epiphysis moves away from the abscess and in adults may be some inches from it. In the example illustrated in Fig. 314 the infection must have occurred shortly before growth ceased because the abscesses are so close to the epiphyses.

A Brodie's abscess often remains quiescent and symptomless for years but sooner or later it is likely to cause trouble. The bone becomes painful and tender, the overlying skin red and œdematous and there may be some fever but the constitutional symptoms are not marked. Recurrent attacks of this nature are a characteristic feature.

Treatment. The abscess is excised together with the dense bone surrounding it *and the wound sutured. Since there are no extensive ramifi*cations in the bone, as with other forms of chronic osteomyelitis, and no scarring of the soft tissues, it is likely that healing will be by first intention.

SYPHILITIC OSTEOMYELITIS

Syphilitic disease in bone is becoming increasingly rare in western countries, so much so that when encountered the diagnosis is easily overlooked. The disease is a true spirochætal infection of bone. The appearances are diverse and many other conditions may be simulated, but certain typical forms occur at different periods of life.

Infants

Epiphysitis. This is a characteristic manifestation during the first year of life. The typical lesion is an osteochondritis affecting the region of the epiphysial disc, usually at the lower end of the femur, sometimes at the upper end of the humerus. Radiographically there is a line of increased density adjoining the epiphysial disc, a line of rarefaction subjacent to this, and then another line of sclerosis. There are thus two lines of increased density ("*white lines*") separated by a line of rarefied bone (Fig. 315). The rarefied bone is necrotic and partly replaced by syphilitic granulation tissue;



Fig. 315. Syphilitic epiphysitis

separation of the epiphysis may occur at this point. If the condition progresses to suppuration, a large abscess involving the joint may be formed. The response to anti-syphilitic treatment is good.

Parrot's Nodes. These are areas of periosteal thickening which occur on the skull around the anterior fontanelle and produce the so-called "hot-cross bun" appearance.

Adolescents

Periosteal Nodes. These may occur on the long bones at any age, but most frequently in the young adolescent. Infection of the periosteum leads to inflammatory changes that terminate in the deposition of new bone beneath the periosteum. They are painless in children, but in adults there may be some aching and tenderness on pressure.

Osteoperiostitis. There is thickening of the periosteum over a large area of the bone and sclerosis of the subjacent bone. It is usually of symmetrical distribution and occurs characteristically in the tibiæ giving rise to the classical "*sabre tibiæ*." The sclerosis is probably due to reduction of the blood supply caused by syphilitic endarteritis of the periosteal vessels.



FIG. 316. Gummatous osteitis of the tibia.

Adults

Gummatous Osteitis. There are several forms :—

(*a*) LOCALIZED GUMMATA of the long bones, commonly the clavicle or tibia. There is a central area of destruction surrounded by a diffuse zone of sclerosis. There may be periosteal bone formation and thickening of the whole bone (Fig. 316).

(*b*) DIFFUSE GUMMATOUS INFILTRATION of the long bones. There is a general osteoporosis with many areas of trabecular destruction.

(*c*) SYPHILITIC DACTYLITIS commences in the medullary region of the metacarpals, metatarsals or phalanges. There is rather more sclerosis and new bone formation than in tuberculous dactylitis which it otherwise resembles (p. 394).

(*d*) GUMMATOUS PERIOSTITIS is found in the sternum, clavicle, ribs, and sometimes in the long bones. When it occurs at a subcutaneous surface an indurated, red swelling is formed and eventually bursts through the skin to form a typical gummat[illegible] [illegible]cer.

ACUTE SUPPURATIVE ARTHRITIS

The synovial fluid has a bactericidal action and there is no good reason to believe that joints are more susceptible to infection than other parts of the body, or that their resistance is lower. The result of unchecked suppuration in a joint is, however, more serious than elsewhere because it causes gross interference with function.

Infection can reach a joint in the following ways:—

1. By the blood stream.
2. By direct spread from a neighbouring focus of infection, usually in bone.
3. By penetrating wounds.

Frank suppuration is usually due to staphylococcal or streptococcal infection although it may be caused by almost any other micro-organism. Blood borne infection originates in a manner similar to acute haematogenous osteomyelitis, the bacteria being derived from a superficial focus such as a boil or an infected tonsil. It may occur at any age but is commoner during childhood and adolescence. Acute suppurative arthritis of infancy, which usually affects the hip joint, is described on p. 147.

Pathology

The synovial membrane becomes acutely inflamed and there is an effusion into the joint which at first is only turbid. If the diagnosis is made promptly, it may be possible to control the infection at this stage and resolution takes place leaving a normal joint. In the absence of treatment the effusion rapidly becomes thick and purulent, and if suppuration [illegible]

into the surrounding soft tissues.

Restriction of movement is an inevitable sequel to prolonged suppuration. The granulations on the opposing surfaces of the joint fuse together and are converted into fibrous tissue (Fig. 317). If the articular cartilage has been destroyed exposing cancellous bone, the fibrous tissue ossifies and the result is bony ankylosis. Destruction of bone and soft tissues, or gross distension of the capsule, may be followed by pathological subluxation or dislocation; this often occurs in suppurative arthritis of the hip in infants.

Signs and Symptoms

The onset is accompanied by *general toxaemia* which becomes more profound as pyarthrosis develops. There is a high swinging temperature characteristic of a closed abscess, and the joint is painful, hot and distended. The point of maximum tenderness is *over* the joint, and not over the epiphysial line as in acute *osteomyelitis*. The joint is held in the position of greatest ease, usually *semiflexion*. At an early stage there is a limited

range of passive movements, but once the articular cartilage has been invaded by pannus, the limb is held rigid and attempted movement causes intense pain—even shaking the bed may be so painful that the patient is apprehensive when anyone approaches.



FIG 317 Chronic suppurative arthritis of the hip followed by fibrous ankylosis Treatment commenced late, twelve days after onset

Diagnosis has to be made from acute osteomyelitis and acute rheumatism. In acute osteomyelitis the temperature is more often sustained than swinging, tenderness is localized to the epiphysial line, and there is a considerable range of passive movements provided examination is sufficiently gentle. Acute rheumatism seldom, if ever, remains monarticular for longer than a day or two. Time must not be wasted by awaiting the result of laboratory examination of the fluid, or the response to the administration of salicylates. When suppurative arthritis is suspected the joint must immediately be aspirated, and if the fluid is cloudy or turbid on naked eye inspection, treatment is commenced at once.

Treatment

Chemotherapy, as with other acute suppurative conditions, has revolutionized treatment. The prognosis as regards movement depends chiefly

on preventing gross suppuration and it is of utmost import to commence treatment at the earliest moment.

The joint is aspirated and the fluid inspected. If it appears cloudy or turbid, a solution of penicillin should be instilled in its place. (It is undesirable to introduce penicillin unnecessarily into an uninfected joint because this has occasionally resulted in infection by a penicillin-resistant organism). Systemic penicillin is also given to control the primary source of infection and deal with any local spread around the joint that may have occurred. The affected joint should be immobilized; the knee or elbow may be enclosed in a bi-valved plaster-of-Paris cast, the hip requires extension with the leg in a Thomas's splint, and the shoulder is supported on an abduction splint.

The quantity of penicillin introduced into the joint is ordinarily 300,000 units in 5 ccs. of water. The injection should be repeated every forty-eight hours until the infection has been controlled as determined by bacteriological examination of the aspirated fluid. This is unlikely to take longer than a week although a small sterile effusion may remain for a considerable time, and a slightly raised temperature may persist for as long as the administration of penicillin is continued. The joint should be kept at rest for at least a week after the fluid has become sterile.

When treatment has been delayed until suppuration is well advanced, the pus may be too thick to aspirate. Operation is then necessary. The joint is opened by a lateral incision and thoroughly washed out with a copious quantity of saline; penicillin is introduced and the synovial membrane sutured, but the superficial layers of the wound are left open for later closure. Very advanced infection requires extensive drainage. The knee is always difficult to drain satisfactorily because of its many recesses; it is perhaps managed best by making two lateral incisions and nursing the patient face downwards.

Arthritis in Pneumonia and Zymotic Diseases

Joint infection sometimes occurs during the course of pneumonia, enteric fever, dysentery, scarlet fever and other exanthemata. The infection may be due to the specific organism of the disease or to associated infection by streptococci or bacillus coli.

Pneumococcal Arthritis. This occurs very occasionally during the course of lobar pneumonia, usually about the tenth day, and it is also seen in children, but not in adults, as a primary joint infection without clinical evidence of infection of the respiratory tract. The severity of the infection ranges from a mild serous synovitis to suppurative pyarthrosis. Complete recovery was the rule before the use of penicillin, and with penicillin the prognosis should be excellent.

Scarlatinal Arthritis. An effusion into one or more joints is not uncommon during the first week or ten days of scarlet fever. It is probably toxic in origin and usually clears up quickly without treatment. At a later stage of the fever there is very occasionally a gross streptococcal infection of a joint.

Gonococcal Arthritis

This is a mild form of suppurative arthritis. It occurs in 1 per cent to 2 *per cent of patients with established urethritis, but since so many acute* infections are now rapidly controlled by chemotherapy this represents a very small fraction of them all. When arthritis has complicated one attack of urethritis, it often recurs with a second attack.

The condition is usually polyarticular and any joints may be involved; the commonest are the knee, ankle, metatarso-phalangeal, wrist, metacarpo-phalangeal and interphalangeal joints in that order of frequency. Occasionally only one joint is infected, *usually a large joint and one that is* much used, for example the knee or ankle, and in coal-miners the elbow and wrist; it is then usual for suppuration to be more severe, the fluid aspirated from the joint is obviously purulent and gonococci are readily recovered from it.

The onset is usually about one to three weeks after the development of acute urethritis, but sometimes later, and occasionally much later. The course may be acute, subacute or chronic. *The acute form is accompanied* by pyrexia of 100°-102°, and the white cell count rises to between 30,000 and 40,000. There is severe pain, the joints are distended with fluid, they are red, hot and tender, and there may be overlying subcutaneous œdema. The more chronic forms are not accompanied by such marked constitutional disturbances, but there may be some leukocytosis; the characteristic feature is a polyarthritis with much pain and gross effusion into the larger joints.

The X-rays show only soft tissue changes unless destruction of articular cartilage is sufficiently advanced for the joint space to be narrowed.

The diagnosis is obvious in the typical case in which acute urethritis is followed in a few weeks by polyarthritis with marked effusion into the joints. In chronic cases, particularly if monarticular, and if venereal infection is denied, diagnosis may be difficult. The synovial fluid contains *an excess of cells but gonococci are seldom demonstrable, even by* culture. The compliment fixation test is positive in a high percentage of infections.

Treatment

The response to penicillin and sulpha preparations is usually excellent, and provided treatment is begun early and the organism is not resistant, resolution takes place without damage to the joint. In neglected infections, the articular cartilage may be destroyed and fibrous ankylosis occurs; bony ankylosis is uncommon.

CHAPTER XI

TUBERCULOSIS

Tubercle bacilli are scattered throughout the world in great numbers and large sections of the population at some period in their lives suffer from sub-clinical infection. Only a proportion, however, develop overt tuberculosis and this is favoured by exposure to an excessively large dose of bacilli, and by a low resistance to disease. The risk of exposure to direct infection by human beings suffering from tuberculosis is a major medico-social problem that has not yet been solved. Exposure to infection by infected milk and food can be controlled; in some countries this has already been achieved, but the position in Great Britain cannot yet be regarded as satisfactory. Individual resistance to tuberculous infection is also controllable to some extent because tuberculosis is a social disease, and although it does occur in all classes, the incidence is greater amongst poorer people. Bad housing and overcrowding increase exposure to infection, undernutrition reduces bodily resistance, and unemployment leads to both overcrowding and undernutrition.

Tubercle bacilli are of two types, human and bovine, the former being responsible for about two-thirds or three-quarters of all bone and joint infections. The human type enters the body by inhalation or ingestion, whilst the bovine type is usually consumed in milk or butter obtained from diseased cattle. In both instances the bacilli pass to the tonsils and to the mesenteric and bronchial glands where small abscesses are formed; from time to time bacilli are liberated into the blood stream from these abscesses.

Bones and joints are never the seat of primary tuberculous infection. Bacilli always reach them from some other focus in the body via the blood stream, and perhaps occasionally via the lymphatic system. The primary focus may be a small abscess in a lymphatic gland which is not itself causing symptoms and which cannot be located by existing methods of examination, but often it is large enough to cause symptoms and its presence can be detected. It is likely that the development of tuberculosis in bone is determined by local injury or some other condition which so devitalizes the tissues as to form a suitable medium for the culture of organisms deposited in them.

In a majority of patients the initial infection is near a joint and both bone and joint are involved (tuberculous arthritis), but occasionally a flat bone or the shaft of a long bone, for example a rib, is affected (tuberculous osteitis). The pathological process is similar in both cases, but the symptoms and course are somewhat different.

TUBERCULOUS ARTHRITIS

Tuberculous arthritis is essentially a disease of childhood; the maximum incidence is between three and five years of age and about eighty per cent of patients are children under fourteen. In childhood the joints most commonly affected in order of frequency are the vertebræ, the hips and the knees. In adults the knee is the commonest joint to be involved; disease of the upper limbs is relatively commoner than in children but it accounts for a minority of infections.

Pathology

The general behaviour of tuberculous infection in bone is similar to that in other structures. There is a stage of invasion, a stage of activity, and a stage of regression and repair.

Invasion. The infection usually commences in the subchondral bone near the periphery of a joint, and sometimes in the metaphysis close to the epiphysial line. The precise position varies with the individual bone and probably depends on the arrangement of the blood supply and the liability to trauma. A focus near a joint is seldom restricted to bone and almost invariably spreads to the joint within a short time. There are occasions, particularly at the knee, when the infection is predominantly synovial, and this is important because the prognosis as regards both healing and subsequent function is much better.

Activity. Tubercle bacilli, having been deposited in the bone at a spot suitable for growth, multiply and form tuberculous giant cell systems; these coalesce and increase in size destroying and replacing normal tissues. The tuberculous nodule thus formed is avascular so the centre degenerates and becomes necrotic, but the periphery continues to expand. The surface of the bone is soon perforated and the joint exposed; there is then rapid dissemination and the whole synovial membrane and articular cartilage become covered with tuberculous granulation tissue. The articular cartilage is eroded allowing further invasion of the underlying bone, and both bone and joint are progressively destroyed and replaced by tuberculous material. The tissues over a large area become hyperæmic and œdematous, possibly accounting for the widespread rarefaction of bone.

ABSCESS FORMATION. A tuberculous abscess (cold abscess) is formed when the surface of the bone or the joint capsule is perforated and tuberculous material passes outside. It tracks along the planes between muscles or within muscle sheaths as determined by the disposition of the deep fascia (Fig. 319, and Fig. 88, p. 129). The abscess is confined by the fascia but may perforate it when the tension rises by reason of the great volume of fluid produced, or the restricted space available. After perforating the deep fascia the abscess becomes subcutaneous, and if it is left untreated, the overlying skin gives way forming a sinus (Fig. 320). The sinus communicates with the joint and secondary infection by pyogenic bacteria is inevitable.

The walls o Its contents consist ilified products of the tissues that have been destroyed. Tubercle bacilli are usually present although they are not easy to demonstrate. Sometimes a great quantity of fluid is produced and as much as a pint a week has been removed regularly from a single abscess.

Repair. Tuberculous arthritis runs a natural course lasting some years, but this is modified by chemotherapy. When the disease is mainly synovial and treatment is begun early, repair is rapid and the structure returns to normal. When there is much destruction of bone the course is



Fig. 318 Fibrous ankylosis of the hip following tuberculous arthritis

shortened, perhaps halved, but a return to normal is impossible. Such bony tissue as *remains recalcifies, but the articular cartilage is not reformed,* nor is the shape of the bone restored. Tuberculous granulation tissue is converted into fibrous tissue, but active tubercles may be encapsulated in it and remain quiescent more or less indefinitely. These tubercles contain living bacilli which can cause recrudescence of the disease, even years later, if they are liberated as the result of injury to the encapsulating fibrous tissue.

Since repair is by fibrous tissue, the ultimate result in most cases is fibrous ankylosis of the joint (Fig. 318). In some regions, particularly the spine, very slow ossification of the fibrous tissue may take place over a

period of years, but as a rule bony ankylosis occurs only when there has been secondary infection. Fibrous ankylosis is an unstable state liable to yield to excessive strain, and since the fibrous tissue may contain encapsulated foci of living bacilli, the condition cannot be said to represent "cure" in the ordinary sense of the word.

During the process of repair the fluid content of an abscess, if there has been no sinus for it to drain through, is slowly absorbed leaving an inspissated mass which shrinks towards the affected joint. The residue becomes fibrosed and calcified in an irregular manner giving a characteristic radiological appearance.

Signs and Symptoms

The early indications of joint disease are pain, spasm and limitation of movement. These findings are not diagnostic of tuberculosis, but they are indicative of some irritative condition of the joint and must be regarded as a danger signal which, especially in children, should never be ignored. In every instance investigation must be pursued until the cause has been determined.

Pain. This is usually an early and prominent symptom. It occurs after involvement of the synovial membrane or articular cartilage and is associated chiefly with movement, being reduced or abolished when movement is restricted by muscle spasm. Sometimes pain is absent throughout the whole course of the disease, and often there is no real pain, but an ache which is worse towards the end of the day or after exercise and is relieved by rest. The onset of pain often follows a minor injury that forces movement beyond the limit set by the muscles. The so-called "night-start" due to relaxation of protective spasm during sleep is not an early sign but a late one, and not very common at that.

Pain is not necessarily localized to the affected joint and is often referred to a distant point that has a nerve supply derived from the same spinal segment. For example, earache may be the first complaint when there is upper cervical caries, and pain in the knee is very common in disease of the hip.

Spasm and Limitation of Movement. Spasm of the muscles controlling the joint is an early and constant sign. Both active and passive movements are restricted, at first perhaps only to a slight extent. Movement may be quite free over part of the range but it is suddenly checked by the muscles, and if the attempt is made to continue the movement beyond *this limit, the bone proximal to the joint is moved instead*. The patient is apprehensive of any attempt to use force.

Limp. This is a characteristic symptom in disease of the lower limb or spine and is often the first abnormality noticed. In spinal disease limp is caused by irritation of the psoas muscle which produces a flexion deformity at the hip. Unexplained limp in a child, even if painless, is an imperative indication for complete examination.

Deformity. There is nearly always some deformity. The position of the joint is determined by the constant pull of the stronger muscle groups and, at a later stage, by actual destruction of the bone.

Swelling. The synovial membrane and periarticular tissues are thickened, and the joint is distended with tuberculous material. The more superficial joints like the knee acquire a typical "boggy" feeling, but the spine and hips are too deeply placed for accurate palpation.

Wasting. The muscles waste rapidly and sometimes to an extreme extent. All muscle groups acting on the infected joint are involved. The wasting accentuates the appearance of swelling and makes it seem greater than it really is.

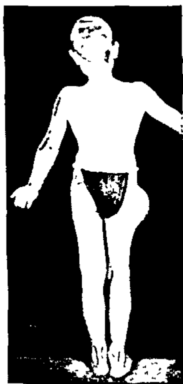


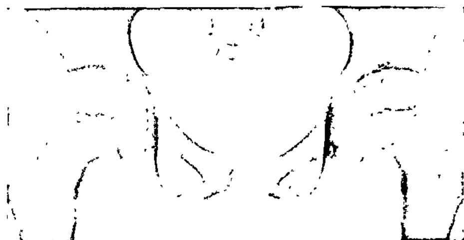
FIG 319 Tuberculous abscess of the hip



FIG 320 Sinuses communicating with a tuberculous hip

sign of disease to be . Abscesses connected with the hip and spine are often large, and usually cold and painless (Fig. 319). A psoas abscess presenting in the groin is sometimes the first indication of spinal caries. Abscesses from smaller joints have not the same opportunity to track along tissue planes and they more readily perforate the skin.

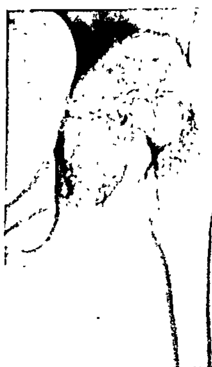
Sinuses. These may form spontaneously when an abscess perforates the skin, or they may follow surgical intervention. The typical tuberculous sinus has a flat, blue-coloured edge surrounded by atrophic skin and is very indolent (Fig. 320). The scars of multiple sinuses are a conspicuous feature of healed tuberculous disease and they may reveal the nature of the original diagnosis many years later.



February, 1945 Narrowing of joint space, irregularity in outline of the head of the femur and general rarefaction



November, 1945 Increasing destruction of bone



July 1947 Recalcification An area of sclerosis is forming around the acetabulum

FIG. 321. Tuberculous arthritis of the hip

X-ray Appearances

Tuberculous arthritis may be present before there is any radiographic evidence of disease and therefore a negative examination shortly after the onset of symptoms does not exclude it. If symptoms persist, further X-rays should be taken at intervals of two to three weeks. Films of the highest quality are essential or early changes in the detail of bone structure will not be shown.

The typical changes are (Fig. 321):—

TRABECULAR DESTRUCTION. The initial focus in bone is not always demonstrable but it may be possible to detect in the juxta-articular or juxta epiphysial region a localized area from which the normal trabecular structure has disappeared. There may be several such areas that later coalesce.

NARROWING OF JOINT SPACE. As the articular cartilage is destroyed, the joint space becomes narrower.

LOSS OF OUTLINE. Erosion of the articular surface of the bone makes the outline of the joint irregular and sometimes fluffy.

GENERAL DECALCIFICATION. There is frequently widespread decalcification of all the bones forming the joint and extending for a distance of an inch or two from it. The margin of this area is often well defined.

DESTRUCTION OF BONE. As the disease progresses, there is an increasing amount of bone destruction.

ABSCESS. A paravertebral or a psoas abscess is nearly always present in spinal disease at a very early stage and is clearly visible in good films (Fig. 88, p. 129).

Diagnosis

In children the clinical signs of irritation of a joint—pain, spasm and limitation of movement—when accompanied by radiological evidence of destruction of bone are sufficient evidence on which to base a diagnosis. When the X-rays are negative, the child should be put to bed and kept there until the symptoms disappear or X-ray changes appear. There is occasionally difficulty, particularly at the knee, when the infection is principally synovial and there is not sufficient destruction of bone to be demonstrable radiologically. The following special tests may then be helpful:—

Aspiration. This is one of the more valuable aids to diagnosis, but the findings in active disease are by no means always positive. A full aseptic technique is essential. The needle should enter through healthy skin, the track must be as long as possible and, if practicable, pass through muscle; the skin is pulled sideways before perforating the deep fascia to act as a valve.

Biopsy of Lymph Glands. The inguinal lymph glands, even when they are not clinically enlarged, provide histological evidence of tuberculosis in a high percentage of infections of the hip and other joints of the lower limb (Seddon).

Arthrotomy. Biopsy of the synovial membrane or bone, formerly an undesirable procedure because it often caused a sinus, has been made reasonably safe by chemotherapy. It gives the greatest number of positive results, although just occasionally it fails to provide evidence of an infection that is subsequently proved to have been present.

Tuberculin Reaction. The Mantoux reaction is probably the most reliable tuberculin test and a positive reaction to a concentration of one in ten thousand is usually held to be diagnostic of active tuberculosis. The reaction may, of course, be due to disease elsewhere than at the suspected joint. It is occasionally negative when there is active disease of bone, and a concentration of one in one thousand often produces a positive reaction when there is not active disease.

The Sedimentation Rate is usually, but not invariably, raised in active tuberculosis, but it is also raised, especially in adults, with other types of arthritis likely to cause difficulty in diagnosis.

Treatment.

Healing of a tuberculous lesion depends principally on the powers of resistance of the patient. Until recently the surgeon has been able to do little more than assist the patient to combat the disease by providing him with the best conditions as regards both general environment and the affected joint. Surgical intervention during the active stage was fraught with danger and the aim of treatment was to secure sound bony ankylosis of the affected joint.

The advent of chemotherapy has modified but not fundamentally altered the position. The new drugs have two functions. The first, which is now well established, is to help destroy the invading bacteria. The second, but this as yet is less securely based, is to permit the application of surgical principles to tuberculous disease—when there is pus, let it out; when there is diseased bone, remove it. And in some circumstances they enable treatment to aim at retaining movement at the diseased joint.

The details of treatment are changing more rapidly than at any time during this century as new drugs are tried, and their effects on surgical procedures are explored. But the general arrangements for treatment remain the same, and provision should be made for all patients, except a few, under each of the following headings:

A. Disease Active
   1. *General environment.*
   2. *Chemotherapy.*
   3. *Local treatment of the joint.*

B. Disease Arrested
   1. *Mechanical or operative protection for the joint.*
   2. *Regular examination over a prolonged period.*

General Environment. There are two important reasons why tuberculous arthritis should receive general treatment as well as local. Firstly to increase the general resistance, and secondly for the benefit of

associated lesions because there must always be a primary focus elsewhere. Associated pulmonary disease has been detected in about 50 per cent of patients, the exact figure varying with the methods of investigation used.

Institutional treatment in an open-air country hospital offers the most favourable conditions for all patients with bone and joint tuberculosis, including those requiring operation. The regime is similar whether the infection is of the bones and joints, or of the lungs. The chief indications are rest, food, air and sun, and the greatest of these is rest. Rest for the joint must be continued until the diseased tissues have healed ; but before this has occurred, the patient's general condition may have progressed to an extent that makes exercise for the rest of the body desirable. This is practicable with disease of the upper limb which can be splinted satisfactorily whilst the patient is ambulant. With disease of the lower limb and spine, however, recumbency may have to be continued much longer.

Chemotherapy. Drugs which kill or inhibit the growth of the mycobacterium tuberculosis are ancillary to other forms of treatment and it cannot be overemphasized that they do not replace conservative methods, particularly rest. Their value, so far as can be told at present, is that

1. they modify the natural history of the disease by shortening the active stage thus reducing the period of immobilization and limiting the amount of bone destruction.
2. they help sinuses to heal, often with remarkable speed, and
3. they may enable bolder surgical measures, which further accelerate the rate of healing, to be undertaken with safety, for example excision of abscesses and sinuses, removal of necrotic bone and arthrodesis.

The antibiotics now in use all have certain disadvantages such as an immediate or delayed systemic reaction following large dosage or prolonged administration. The most important difficulty, however, is the growth of resistant strains of the infecting organism which occurs with disconcerting rapidity. The time it takes for resistance to develop varies with the drug from about one to three months. Fortunately the emergence of resistant strains is delayed by administering several drugs together and a common practise is to give streptomycin, para-amino-salicylic acid and isonicotinic acid hydrazide at the same time. Chemotherapy should be begun as soon as a firm diagnosis has been made and continued without intermission for four to six months. A second course may be given after an interval if operation becomes necessary.

STREPTOMYCIN has been in use longer than the other anti-tuberculous drugs. It gives rise to a greater number of serious complications ; these are commoner after large doses and long continued administration, but they sometimes occur after comparatively little has been given. The commonest complications are vertigo and deafness, and the latter is often permanent ; conditions such as eosinophilia, pellagra-like rashes, jaundice and purritis are seen from time to time. A usual dose for a child over ten years old is 1 gram intramuscularly each day for three to four months.

Para-amino-salicylic Acid (P.A.S.) is unpleasant to take because it causes nausea but there are few complications provided not more than 10 to 12 grams daily are given by mouth. When used alone, resistant strains appear more quickly, but when given at the same time as streptomycin the emergence of resistant strains is delayed.

Isonicotinic Acid Hydrazide (I.N.A.H.) and related chemicals such as Iproniazide give rise to few complications all of which are mild. It is never used alone, but when given with the two drugs already mentioned, it seems to delay further the development of resistant strains. The dose is 3 to 4 milligrams per kilogram of body weight daily.



Fig 322. Tuberculous focus in the neck of the femur, the joint is also involved

Local Treatment. This may be

(*a*) *Conservative.*
(*b*) *Operative.*

Conservative Treatment consists in placing the joint at rest in the best functional position until healing has occurred. The method of fixation varies with the individual joint but there are certain general requirements :—

1. Complete immobility of the joint.
2. Fixation in the position giving the best function for the ankylosed joint.
3. The apparatus should permit of easy inspection to detect abscess formation.
4. The joint surfaces during the active stage usually should be kept apart to prevent the softened bone being distorted by the pressure of the muscles in spasm.
5. The joint surfaces during the stage of regression should be allowed to come together to facilitate consolidation (except when the aim is a movable joint).
6. Fixation must be continued until the disease is quiescent and consolidation well advanced.

7. After the period of recumbency, it is usually necessary to protect the *joint by mechanical or operative methods until there is secure* ankylosis, but the number of occasions when a useful range of movement remains and can safely be permitted is increasing.

OPERATION. Opinion has fluctuated at different times and in different countries between early operation and the complete denial of the value of surgery, and there is still no general agreement. As experience with chemotherapy increases and new drugs are elaborated, there is a tendency to make greater use of operative methods during the active stage. The number of patients who might be helped by operation is limited and a clear policy cannot be reached quickly, but the way is being explored.

It is becoming apparent that operations on bone in the diseased area may stimulate healing. The trend is, therefore, towards the removal of sequestra and necrotic bone, and the excision of sinuses and thick-walled abscesses. Osteotomy and arthrodesis are also being performed earlier than formerly. The indications are still tentative but the following procedures are now attempted in some circumstances during the active stage:

1. Synovectomy, particularly at the knee, when the disease appears to be restricted to the soft tissues.
2. Evacuation or excision of an abscess followed by suture of the wound. Operation is often the only way of emptying a paravertebral abscess.
3. Excision of the joint and arthrodesis when it is clear that movement cannot be retained.
4. Excision *of a focus that is completely extra-articular is usually successful*, and it is now being tried even when it communicates with the joint.

Protection After Arrest. EARLY. On those occasions when the aim is a movable joint, mechanical protection is unnecessary although some restriction of activity may be desirable for a time. Most patients are, however, still destined to have a stiff joint and then protection is essential until there is sound consolidation. This is provided by means of apparatus, for example a spinal brace or a plastic hip spica.

LATE. Healing takes place by fibrosis and often there is extensive scarring in and around the joint. This fibrous tissue is a potential danger of considerable importance because it often contains encapsulated foci of living tubercle bacilli. An injury of sufficient violence to damage the scar is likely to free the organisms and cause the disease to flare. Moreover deformity may gradually develop at a joint such as the hip when there is only fibrous ankylosis. No joint without bony ankylosis can be regarded as secure unless it has healed with good movement and there is no scarring.

Bony ankylosis does not occur spontaneously, except sometimes in [illegible] secondary infection. Continued protec- [illegible] fore desirable, particularly for the joints of the lower limb which are necessarily exposed to many stresses in the ordinary course of life. Apparatus is most irksome, and since few patients tolerate it indefinitely, the question of arthrodesis must arise.

Arthrodesis is of undoubted value when the disease is arrested. It is better to use an extra-articular method when this is practicable, for example at the hip (Fig. 323). Antibiotics have, however, made the operation reasonably safe even when it is necessary to open the diseased area, as at the elbow, knee and ankle. The best time for arthrodesis is when the patient has withstood the clinical test of living in normal conditions wearing protective apparatus for two or three years without reactivation of the disease.



Fig 323 Arthrodesis of the hip by Brittain's method in a *patient with tuberculous disease (by courtesy of Mr H. J. Seddon)*

Follow-up. This aspect of treatment is often overlooked but it is important, both for the welfare of the patient and for accurate assessment of different methods of treatment, that regular examination is carried out over a very prolonged period. It should be arranged whenever possible by the team responsible for the original treatment and with full records available at the time. The investigation should include not only the patient's general health and the physical condition of the diseased joint, but also his home circumstances and conditions of work. Those who have once suffered from clinical tuberculosis are more likely to do so again than is the rest of the population, and therefore it is important to ensure that they remain in a satisfactory environment.

TUBERCULOUS OSTEITIS

There are certain positions at which tuberculous infection is essentially an osteitis or periostitis and joint involvement is unusual. The common sites are the fingers and ribs, the sternum is occasionally affected, and the mastoid may be involved secondarily to middle ear disease; infection of nearly every other bone has been described on rare occasions. The process is essentially the same as in tuberculous arthritis; the mode of infection and the pathological changes are similar, but because there is a difference in structure and function, the symptoms and course are somewhat different.

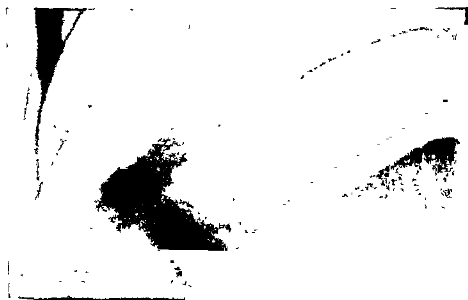


FIG. 324. Tuberculous osteitis of a rib There was no recurrence four years after resection.

Tuberculous osteitis. The classical example is tuberculous dactylitis which is described on p. 394.

Tuberculous Periostitis. This is exemplified by infection of the ribs (Fig. 324). The infection may be blood-borne, or it may spread from a cold abscess that has tracked from the spine along an intercostal space. The disease spreads over the surface of the rib deep to the periosteum; the bone is eroded, an abscess forms, and unless treatment is prompt, the overlying skin gives way leaving a sinus, or else the abscess tracks inwards and infects the pleura.

CHAPTER XII

CHRONIC ARTHRITIS

Attempts to classify chronic arthritis are gravely handicapped by the vagueness of our conceptions as to the ætiology, and by the difficulty of interpreting the histological material. Although the terminology has become so diverse as to deny understanding to all but the professional rheumatologist, comparatively little real progress has been made during centuries except to separate as clinical entities arthritis due to metabolic diseases such as gout, and specific infections like gonorrhœa. There seems, therefore, to be no advantage, in our present state of knowledge, in departing from the time-honoured classification introduced many years ago by the Garrods —rheumatoid arthritis and osteoarthritis. These terms correspond closely with atrophic and hypertrophic arthritis of American usage.

The following simplified statement of the position has the merit both of being comprehensible and of providing a practical working basis for investigation and therapy. More elaborate accounts are apt to lose in clarity as they increase in detail.

The author accepts the view that osteoarthritis is essentially a process resulting from damage to the articular cartilage. The cartilage provides a delicate bearing surface somewhat resembling a white-metal bearing in a motor-car engine, and if the congruity of the surface is disturbed, the bearing ceases to run true and it soon wears out. Damage to the cartilage may result from trauma, mis-alignment of the joint, or disease of the underlying bone. Rheumatoid arthritis is amongst the diseases that may damage the cartilage, thus accounting for the constitutional orgin of some cases of osteoarthritis.

Rheumatoid arthritis, on the other hand, appears to be a specific disease process, or possibly a whole series of diseases of different ætiology. The course varies according to the severity of the attack, the resistance of the patient, and the age. The response of the tissues at different ages may well be one of the major factors determining the course. In children the disease is usually acute and is accompanied by fever and general involvement of lymphatic tissues ; in early middle-age it tends to be less acute and the classical rheumatoid picture is seen ; in later life the tissue reaction is yet slower and therefore the opportunity for mechanical factors to be superimposed is greater.

Rheumatoid arthritis and osteoarthritis, although often pursuing distinct and typical courses, are not always clear cut entities, either clinically or pathologically ; many cases are atypical, and sometimes the two conditions are superimposed and the pathological picture is [illegible]

RHEUMATOID ARTHRITIS

(*Synonyms*) Atrophic Arthritis, Proliferative Arthritis, Ankylosing Arthritis, Arthritis Deformans

Ætiology

Little definite is known about the ætiology of rheumatoid arthritis although, as one of the greatest scourges of mankind, it has given rise to a deal of speculation. The tragic consequences of the disease, and the relative impotence of the medical profession when treating it, have fostered the growth of "cures" of all types and driven the unfortunate sufferers into the willing hands of every kind of qualified and unqualified "therapist." Most theories as to the ætiology are speculative and are based on the results, and even the apparent results, of treatment. But since the course in a particular patient is unpredictable, since benefit may follow any treatment that is lavish of personal care and sympathy, and since hope springs eternal, statistics have not always the significance that their authors attach to them and definite conclusions can seldom be drawn.

The present tendency is to regard rheumatoid arthritis as a member of the now fashionable group of "collagen diseases". There is circumstantial evidence to support this view, but intensive, world-wide research into the physical and chemical behaviour of the collagen molecule has not yet provided an acceptable explanation of the nature or the cause of the disease. A somewhat different but parallel line of thought is emphasizing the importance of "stress" as a precipitating factor. It has long been known that the onset of symptoms often corresponds with a period of mental anxiety or physical fatigue, but the theories that have been elaborated to explain this association are far from complete. Neither of these concepts is sufficiently clear to permit precise formulation and much further work will be necessary before either or both of them, for they are not antagonistic, can be substantiated or rejected.

Two of the older observations regarding ætiology have still to be taken into account. The first is heredity and this may well be a factor because different investigators have found that there is a familial association if collateral branches of the family are taken into account. There is, however, no information as to whether it is a physical attribute that is inherited, or an environment.

The second is the doctrine of focal infection which has been the attractive subject of many enquiries for half a century. It is now clear that neither focal infection, nor any known type of bacterial or virus infection has a part in the disease process. Nevertheless there have been occasions when removal of a focus of infection has been followed by improvement and it is possible that the infection has acted as a precipitating agent. It seems, therefore, that it is necessary during the early stages to search for concealed infection and to treat such as may be found, but this does not justify the speculative removal of important organs just because a few bacteria can be demonstrated.

Pathology

The two types of arthritis remain more or less distinct, but mixed forms showing osteoarthritic changes superimposed on predominantly rheumatoid disease are not uncommon. The typical changes in rheumatoid arthritis (Plate V) are :—

Synovial Membrane. The process begins with a cellular infiltration of the subsynovial tissues and this is followed by proliferation of the synovial cells. The synovial membrane thickens, the inner surface becomes rough and granular, and later is heaped up into ridges and fringes. The latter may grow to a considerable length and float free in the joint like the tentacles of a sea-anemone in a rock pool (*villous proliferation*). Such a fringe is liable to be nipped between the bones and cause acute symptoms. A "pannus" which appears to be derived from the synovial membrane spreads slowly over the articular cartilage. The pannus is at first very vascular, but later it is converted into fibrous tissue.

Joint Capsule. The capsule proliferates and becomes a mass of dense fibrous tissue. The new tissue contracts and restricts movement.

Articular Cartilage. The changes are degenerative and are probably due to interference with its nutrition caused by the spread of pannus, and perhaps by fibrosis of the underlying bone. The cartilage loses its smooth, shiny appearance and changes to a dusky grey; it becomes gradually thinner and finally disappears. The bone thus exposed is not eburnated, as in osteoarthritis, but remains cancellous. Erosion of the cartilage is often patchy, and when areas of erosion on the opposing surfaces of the joint are in corresponding positions, granulation tissue spreads between them; the granulations are later converted into fibrous tissue producing fibrous ankylosis, and if ossification occurs, bony ankylosis.

Bone. The inflammation extends to the subchondral bone either through the articular cartilage or by spreading in from the edge. There is cellular proliferation in the marrow spaces and resorption of bony trabeculæ. Later there may be reactive hypertrophy at the margins of the cartilage.

Muscles. There is rapid and often severe wasting of the skeletal muscles. Inflammatory nodules consisting mainly of lymphocytes and plasma cells are formed in the perivascular connective tissue. At times the fibrous tissue proliferates between the muscle fibres and eventually destroys them. This makes it difficult, and sometimes impossible, to regain a useful range of controlled, active movements, even if passive movements can be restored by arthroplasty.

Skin. There are usually atrophic changes around the joints, and small nodules, similar to those found in the muscles, are often formed in the subcutaneous tissues, particularly of the fingers and forearm. These nodules consist of vascular connective tissue, usually partly degenerate.

Physiological Disturbances. Many have been described, but none are constantly present. The blood chemistry has been investigated in great detail but no alteration of significance has been found in the concen-

PLATE V



Rheumatoid Arthritis of the Knee

tration of any of the mineral salts or amino-acids. In view of the popular ideas about a meat diet, it is noteworthy that no disturbance has been detected in the metabolism of nitrogen, or in the acid-base equilibrium of the blood. Blood phosphatase is not raised. The blood serum shows no constant change in agglutinins, antifibrolysin titre or precipitin reaction. Hepatic and renal function are unaltered, but the basal metabolic rate is sometimes lowered and the sugar tolerance reduced.

Clinical Features

Rheumatoid arthritis is essentially a disease of the first half of life and has a maximum incidence in early middle age. Women are affected nearly twice as frequently as men. The affection is seldom monarticular, even to start with, and it is commonly of symmetrical distribution. The order of frequency with which the joints of the limbs are involved when the disease is fully developed is fingers, knees, elbows, tarsus, shoulders, hips.

The onset is usually insidious beginning most often in the hands and feet and spreading centrally up the limbs to involve the larger joints. Sometimes the first complaint is of the large joints, usually the knees, and the hands and feet are not involved until later. In older people there may be no constitutional disturbance at any time but a very gradual increase of pain, stiffness and deformity developing over a number of years. On rare occasions the attack is fulminating and accompanied by a high temperature when it may be mistaken for rheumatic fever.

As a rule the acute stage is accompanied by a greater or lesser degree of malaise. There may be a low, irregular fever and loss of weight. General enlargement of the lymphatic glands is not uncommon, and the spleen may be palpable. There is usually anæmia of secondary type. The erythrocyte sedimentation rate is frequently raised and this gives some indication of activity and progress.

With the typical, insidious onset there is at first only a little pain, tenderness and stiffness in the affected joints lasting for a short time. There may be several such attacks before swelling is first noticed, but as the disease is established, swelling of the joints becomes marked and the muscles atrophy, sometimes to an extreme degree. Pain and tenderness are severe, and muscle spasm prevents almost all movement. The skin becomes atrophic, and looks smooth and shiny. The nails may be brittle and discoloured. Subcutaneous nodules frequently develop in fingers and elsewhere. Sweating is free particularly in the palms of the hands and soles of the feet, and the sweat often has a characteristic odour.

The swollen joints may be slightly red and hot, and the skin seems tightly stretched over them. There is usually some effusion, although this is more obvious in the larger joints than the smaller. The joints have a typical fusiform, spindle-shaped appearance which is most marked in the fingers (Fig. 329). Swelling of the large joints is accentuated in appearance by muscle wasting. Flexion deformities develop rapidly; they are most difficult to correct, and unless the utmost care is taken with splinting, the joints may dislocate or subluxate. In an established case the deformity

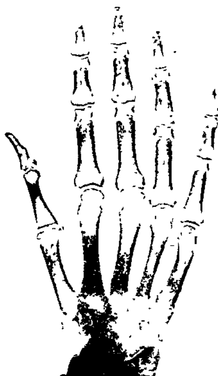


Fig 325 Rheumatoid arthritis at an early stage showing rarefaction near the joints of the wrist and fingers



Fig 326 Rheumatoid arthritis at a later stage with more extensive decalcification. There are "punched out" areas of trabecular absorption at the head of the first metacarpal and subluxation of the metacarpo-phalangeal joint.



Fig. 327. Advanced rheumatoid arthritis with generalised decalcification.



Fig 328 Ankylosis of the hip following rheumatoid arthritis

of the hand with ulnar deviation of the wrist and fingers, as shown in Fig. 330, is quite characteristic.

The condition is subject to remission at any time but the prognosis should be guarded because it cannot be foretold if a remission is temporary or permanent. The disease, even if treatment is unsuccessful in shortening its duration, eventually subsides. If it is arrested at an early stage, the joints may return almost to normal; at a later stage the degree of functional recovery depends upon the amount of structural damage and the care with which deformities have been prevented. In a very severe case the feet are rigid and the toes clawed, movement at the hips and knees is painful and

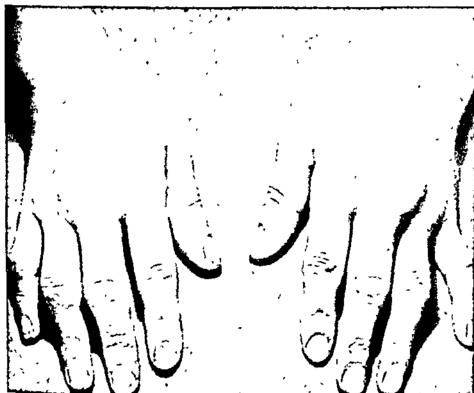


FIG. 329. Rheumatoid arthritis in the acute stage

greatly restricted, the hands are stiff, the fingers distorted, and even the elbows and shoulders may be involved. Fortunately few patients are reduced to this pathetic condition; a majority show some degree of functional recovery and obtain a good range of movement at many joints although at others it may remain painful and restricted.

X-rays (Figs. 325 to 328). The first demonstrable change is swelling caused by effusion into the joint and soft tissue thickening. This is followed by a general decrease in density of the juxta-articular region which later may become extreme and involve the whole end of the bone. There may be one or more "punched-out" areas of trabecular absorption. The joint space becomes narrowed as the articular cartilage is destroyed and ultimately there may be bony ankylosis. Marginal lipping often develops during phases of temporary or permanent arrest.

Treatment

Rheumatoid arthritis is a systemic disease with local manifestations in the joints. A variety of factors play a part in shaping its course. Environment, sex, age, emotional balance, physical and mental stress and body mechanics are all woven into the picture. One or other may predominate, but all may be concerned, and all must be considered when assessing an individual patient ; there is no panacea and no specific remedy.

The hope that cortisone or an allied substance would prove to be a cure has faded and the general lines of treatment remain as before. The aim is to shorten the course of the disease by providing the best general conditions, physical and mental, and to ameliorate the severity of the symptoms by local treatment designed to aid resolution, maintain function and prevent deformity. The following measures, some or all of which may be required for any one patient, are in general use :

GENERAL TREATMENT.

Regimen.
Medicinal.

LOCAL TREATMENT.

Physical.
Operation.

General Treatment. REGIMEN. Rest for both body and mind is the first essential but economic conditions make this perhaps the hardest of all therapeutic measures. Mere absentment from work is not synonymous with rest and ideally there should be the right environment and freedom from all financial, domestic and social worries ! The duration and completeness of physical rest depend on the acuteness of the attack. A period in bed is necessary whilst there is fever or tachycardia, but in a less acute case it may be sufficient to adjust the daily regime to allow set periods of rest.

The judicious use of sedatives is important for the relief of pain. Aspirin, phenacetin and codein are usually sufficient but most of the barbiturates will be found helpful should the need arise. Early splinting also prevents pain, and if carefully done, an analgesic may be required only before the daily movement of the joints. Attention should also be paid to the skin, and when there is excessive sweating the whole body should be washed twice a day.

The diet should be well balanced—that is about the limit of scientific knowledge concerning diet in arthritis. The popular views on the harmful effect of red meats date back to the days when a man might consume a leg of lamb at a sitting and still call for more. The calorie intake should probably be restricted to the minimum necessary for the amount of work being done ; it should be low whilst the patient is in bed and then should be raised as activity increases. The composition of the diet should follow the previous dietetic habits and preferences of the patient with adjustments to ensure a sufficiency of all essential components.

It is very difficult to evaluate impartially many remedies that are so enthusiastically advocated in *different quarters*. Although each is sometimes followed by improvement, the results are not consistent and it is difficult to distribute credit between the alleged remedy and associated general measures. *This applies particularly to treatment in spas and* watering places which have proved their value during many centuries. Conditions in such places can approach the ideal—a regulated life with balanced rest and exercise, a wholesome diet and facilities for local treatment of the joints.

The value of vaccines, non-specific shock therapy and the various mechanical methods of raising the general body temperature is equally difficult to assess. There is no reason to believe they have a specific action, nor is there statistical evidence that they influence the course of the disease. On the occasions when they appear to help, the improvement is just as likely to be due to other factors, or even to a natural remission.

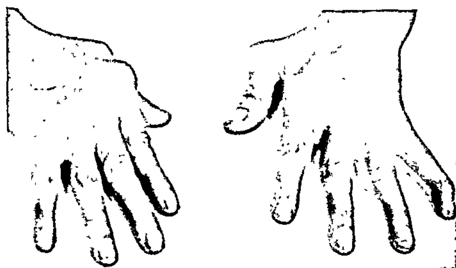


FIG 330. Oldstanding rheumatoid arthritis showing the deformity of the hands.

Focal Sepsis, if it exists, should be eliminated as soon as possible, but there is no case for the indiscriminate removal of every organ that can harbour bacteria. The teeth, tonsils and nasal sinuses are readily accessible to examination and expert advice on their condition should be obtained. A careful history usually shows if there is reason to suspect an abnormality of the gastro-intestinal or genito-urinary tracts, and elaborate and exhausting investigations should be avoided unless there is a very real indication.

Medicinal. No drug yet discovered has a specific action in the treatment of rheumatoid arthritis. Cortisone and Butazolidin act only as suppressives. Some preparations of gold do occasionally appear to arrest the disease and they are still the mainstay of medicinal treatment. All these drugs are dangerous, some are very dangerous, and they should be prescribed with care.

Gold has an old-established place from which it has not been dislodged by any of the newer drugs. There is evidence that in a limited number of patients it brings about arrest or amelioration of the disease, often without later recurrence. It should, however, be given early, certainly within the first year, because it is seldom of great benefit in the chronic stage. Several preparations are in common use, and all carry a risk of complications, usually dermatitis. The reaction may be very severe, and although it can be controlled with BAL, this treatment should only be given where laboratory facilities are available.

Cortisone and allied preparations are now known to act by suppressing the manifestations of the disease rather than by arresting it. Indeed, there is often radiological evidence of progress whilst they are being given ; after withdrawal there is sometimes a clinical exacerbation, and it is thought that the frequency of natural remissions is reduced. These drugs must therefore be regarded as palliative, and because of the unpleasant and often serious complications, they are thought at many clinics to be too dangerous for general use. It is, however, argued by some that low dosage causes few side-effects and is worth while for selected patients because it may give moderate relief. Hydrocortisone is usually preferred to cortisone because of its greater potency, but the claim that it causes fewer complications has yet to be substantiated. The possibility of combining it with other drugs that will act as cortisone "sparers" is being explored.

Cortisone produces a well-marked euphoria and readily becomes a drug of addiction which is difficult to withdraw. The common side-effects are an increase in weight and rounding of the face due partly to water retention, and partly to deposition of fat. Amongst the more serious complications are amenorrhœa, hypoglycæmia and diabetes, depressive psychosis with suicidal tendencies, and exacerbation of cardiovascular and renal disease, of peptic ulceration and tuberculous infection.

It is probable that there are some indications for cortisone but they are not yet generally accepted. It is clear, however, that it is so dangerous a drug that until more is known it should be prescribed only by the few physicians who have a wide experience of its use.

Butazolidin is now widley used but most probably it acts only as a suppressive without having any real effect on the course of the disease. Like the other remedies it is dangerous and complications occur in one out of every two or three patients. These vary from dermatitis, œdema and nausea to anæmia, leukopœnia and agranulocytosis. Reactions are probably due to personal idiosyncrasy and are seen most often during the first few weeks. They may, however, arise later so the maintenance dose must be kept very low and the blood examined regularly.

Local Treatment. PHYSIOTHERAPY can be of great value if skilfully managed but harm may be caused by attempting to "force the pace". There are four procedures available—rest, exercise, heat and massage. The last three are additive in their fatigue effect and it is essential to regulate treatment so as to avoid both fatigue and pain.

REST. Unnecessary movement is contra-indicated during the initial acute phase and the joints should be placed at rest by splinting in the best functional position. This is conveniently managed by bandaging the limbs to light plaster-of-Paris splints. The splints should, however, be taken off daily and each joint exercised within its painless range to prevent unnecessary stiffness. Particular care is necessary to prevent flexion contractures of knees, hips, fingers, wrists and feet; if they are doomed to ankylosis in spite of treatment, let it be in the best functional position.

EXERCISE. Activity is increased as the condition begins to improve. Splints are removed at first only once or twice a day for active and passive movements; later they are discarded during the day, but they should be worn at night for as long as there is a risk of deformity developing. Exercises are graduated to avoid fatigue, and they should include all muscle groups, not only those of the affected parts. Treatment under water in a warm bath is often of assistance because the support given to the limb facilitates active movements and reduces muscle spasm.

General postural defects are common in patients of asthenic build, and these form a large proportion of those affected with rheumatoid arthritis. Although such defects are not the cause of the disease, correction may improve the general health and materially assist recovery. Remedial exercises and postural re-education are therefore of value, and particular attention should be paid to the muscles of respiration and those controlling the abdomen.

HEAT. During the acute stage heat should be avoided; it makes the pain worse, possibly because it increases existing congestion, and it increases effusion into the joint. In the sub-acute stage, superficial heat helps to reduce muscle spasm and may be comforting. With more chronic disease short-wave diathermy is often helpful. Full length heat baths have rather a different function because they induce general sweating and raise the body temperature; they are very fatiguing to a weak patient and should be prescribed with care and administered with caution.

MASSAGE, when skilfully administered, has the effect of "loosening up" joints and muscles and plays an important part in the treatment of arthritis. Both venous and lymphatic flow depend in part on movement of joints and muscles; fluid in the intercellular spaces becomes stagnant when movement is prevented by disease, and massage probably achieves its effect by assisting the blood and lymphatic circulation.

Hydrocortisone administered by intra-articular injection is under trial but there is disagreement as to its efficacy. There is little doubt that it often brings temporary relief but the duration and the effect on the subsequent course are uncertain. The quantities given are so small that there is little risk of a general reaction.

Operation. ARTHROPLASTY presents great problems because of the tendency to fibrous tissue formation; not only do the joints stiffen again as time passes and fibrous tissue is re-formed, but the atrophied muscles often fail to recover sufficiently to give reasonable control. The chief

difficulty is in connection with bilateral ankylosis of the hips, the knees and the elbows. Two stiff hips make sitting impossible and moving about a matter of great difficulty ; even a few degrees of movement are, therefore, greatly appreciated and an arthroplasty may seem worth while to the patient even when the result is a disappointment to the surgeon. Arthroplasty of the elbow is usually fairly successful and provides a useful range of movement ; the range selected should, however, be that which will be of most convenience to the patient, and the need most often expressed is not, as might be expected, to put the hand to the mouth, but to attend to the toilet when at stool (Fig. 331). Two stiff knees are a serious encumbrance, always getting in the way and making it hard to rise from a chair, but unfortunately no reliable arthroplasty is yet available.



FIG 331 Arthroplasty of the elbow in rheumatoid arthritis showing the range of active movement.

ARTHRODESIS is indicated for painful fibrous ankylosis, and sometimes for the correction of deformity. It is required chiefly at the foot, knee and wrist. The methods used are the same as when performing arthrodesis for other conditions and are described elsewhere.

Still's Disease

This is an uncommon condition occurring during childhood. As far as is known it is fundamentally the same disease as rheumatoid arthritis, although more acute (p. 434). The onset is accompanied by fever up to 102° or 103°. There is general enlargement of the lymphatic glands which become hard and tender although they remain discrete. The spleen also is enlarged and palpable. Sweating is profuse. Anæmia may be severe, and there is often leukocytosis. The joints present a typical fusiform appearance, and muscle wasting may be rapid and extreme (Fig. 332).

Cortisone is usually given but the immediate relief may be less dramatic than with adults and the ultimate effect on the course is uncertain. Rest is desirable to start with. This is best arranged on a full length plaster bed which not only prevents deformity, but is often followed by improvement in the general condition. All joints should be moved daily, and activity resumed as early as possible. Exercise in a warm pool, preferably saline, can be helpful at an early stage.

Contractures develop rapidly unless they are carefully guarded against. It may be impossible to stop joints becoming stiff but there is no reason why this should not be in the best functional position. The grotesque



FIG 332 Still's disease

deformities that are sometimes seen should not be permitted—even the hands can be controlled.

Ankylosis, fibrous or bony, is a common sequel. Surgical intervention may be considered after some years when the disease is completely quiescent and the likelihood of subsequent fibrosis is smaller. In the meantime, even when the joints are rigid, the muscles should be kept working by voluntary contraction and faradism ; if the muscles retain some power of contraction, it may later be possible by multiple operations to make these unfortunate cripples able to look after themselves, and even become economically self-supporting.

OSTEOARTHRITIS

(*Synonyms*) Hypertrophic Arthritis, Degenerative Arthritis

Ætiology

The view is taken, as has already been explained, that osteoarthritis is primarily a mechanical disorder caused by wearing out of the joint because of lack of congruity of the joint surfaces (p. 134). Mixed types also occur in which the original damage to the articular cartilage is due to rheumatoid arthritis.

Osteoarthritis is essentially a condition of the second half of life but it is only too often seen at an earlier age as the result of trauma or disease of the joint. It is frequently monarticular although bilateral involvement of the knees and hips is common. It occurs principally in weight-bearing joints, and therefore in the joints of the lower limb; the shoulder joint seldom undergoes osteoarthritic changes because it is not in compression, but the elbow is sometimes involved, and the wrist more frequently as the result of trauma. The spinal joints proper, i.e. the lateral intervertebral joints, are not weight-bearing, and spinal osteoarthritis is much less common than is usually supposed. Lipping of the vertebral bodies has a different significance and must not be confused with osteoarthritis (pp. 67 and 96).

Heberden's Nodes. These are small swellings occurring in elderly people, usually at the terminal joints of the fingers, which are caused by proliferation of bone at the margins of the joints (Fig. 333). They are difficult to classify because although the pathological changes are those of osteoarthritis, the distribution and mode of onset are suggestive of a constitutional cause; they are probably examples of a mixed type of disease.

Malum Coxæ Senilis. Arthritis of the hips occurring in the elderly may sometimes be due to disease of mixed type, but often it appears to be the mechanical result of congenital subluxation or shallow acetabulum (p. 174), and on some occasions it develops for no discoverable reason.

Pathology

The process begins in the articular cartilage and it is possible that all the subsequent changes take place as a reaction. The synovial hypertrophy and capsular thickening may well be stimulated by fragments of degenerate cartilage that have become free in the joint, and the changes in bone, as Trueta has shown, could be the result of an attempt at repair.

Articular Cartilage. The process is degenerative in character. The cartilage loses its smooth, shiny surface, it becomes soft, splits into tiny fragments (fibrillation), and finally flakes off. The whole surface of the joint is not affected at once but only circumscribed patches which, at any rate at the hip, are usually at non-pressure areas (p. 175). If the condition progresses, all the cartilage is involved in time. At some areas it becomes

PLATE VI



Osteoarthritis of the Knee

very thin and may disappear entirely, whilst at others it is lifted up by new bone forming beneath it.

Bone. There is a general increase in vascularity which leads to trabecular absorption in some areas and deposition of bone in others.

Osteophytes. Capillary loops spread into the undersurface of cartilage which becomes calcified. The blood vessels continue to proliferate and the new bone, still covered with a layer of cartilage, gradually extends. At first there is only a little sharpening of the edges of the bone but later osteophytes are formed.





Fig. 333. Heberden's nodes are due to osteophytic outgrowths around the terminal interphalangeal joints. The photograph and X-ray are of different patients.

Eburnation. The bone lying beneath degenerate cartilage at areas where anatomical considerations make expansion impossible becomes dense and eburnated. Cancellous bone and the contained marrow are not exposed as in rheumatoid arthritis and therefore bony ankylosis does not occur.

Cyst-Like Spaces filled with yellow gelatinous or fibrous material develop in the subchondral region. They communicate with the joint and may contain fragments of articular cartilage that have entered through the stomata. It has been suggested that the cysts increase in size as the result of pressure changes during movement; this may also explain the layer of dense bone that surrounds them.

Synovial Membrane. Hyperplastic changes begin at an early stage, perhaps as the result of an attempt to remove the free fragments of articular cartilage. The synovial cells proliferate and become heaped up to form villi which project into the joint; a curtain of pedunculated tags often forms around the articular margin and sometimes the entire synovia is involved. Intra-articular adhesions are common.

A hypertrophic synovitis of this type is often found, particularly at the knee, before there is any radiological evidence of osteoarthritis (p. 229). Unless this is remembered a mistaken diagnosis of rheumatoid arthritis can easily be made.

Capsule. Sometimes there is little change but often there is extensive fibrous tissue proliferation in the sub-synovial layer and capsule. The process is progressive and ultimately the capsule, greatly thickened, is converted into a massive scar. The newly formed tissue contracts causing deformity and restriction of movement.

Muscles. Lack of use causes wasting but there is not the extreme atrophy of rheumatoid arthritis, nor do the muscles become fibrosed in a similar way.



of the hip with slight e joint, cysts in the upper ...w bone formation around the head of the femur

Clinical Features

The onset of symptoms is usually very gradual but it may be accelerated by a minor injury, such as a sprain. At first there is slight stiffness of the joint which interferes with a particular movement and is noticeable only after exercise; pain begins rather later and is associated with movement. Progress is slow but steady and may be appreciable only over a period of months or years. The affected joints gradually become stiffer, and pain on movement greater, until finally a stage may be reached at which all useful movement is lost and there is extreme pain on attempting to use the limb.

Pain. This is not proportionate to the extent of the bony changes but depends more on soft tissue involvement and therefore X-rays give no

indication of the amount of pain there is likely to be. Newly-formed osteophytes and hypertrophied synovial tags at the articular margins are often both painful and tender to pressure.

Pain is not as a rule felt during movement through the free range, only when forced beyond it. It tends to be worse on first moving after a period of rest, for example on getting out of bed in the morning, or after sitting in a chair for some time. It wears off as the stiff joint is loosened by exercise, but it is worse after exercise carried to the point of fatigue.

Pain is sometimes increased by warmth, as when in bed at night; this is possibly indicative of an active process in bone such as "cyst" formation. Pain at night also occurs in advanced disease with great limitation of movement and is caused by unconscious movement during sleep.



FIG 335 Osteoarthritis in the knee There is narrowing of the inner half of the joint space, lipping of the femoral condyles and sharpening of the tibial spines



FIG 336 Osteoarthritis of the knee affecting principally the patello-femoral section of the joint The space between these bones is greatly narrowed.

Limitation of Movement. At first this is slight but it gradually increases. It may be caused by alteration in the shape of the articular surfaces, by impingement of painful osteophytes or hypertrophied synovial membrane, and at a later stage by contraction of periarticular tissues. Muscle spasm is not marked, but it does occur as a protective measure when the painful point in movement is reached.

Deformity. Alteration in the alignment of the articular surfaces and soft tissue contraction both cause deformity. It is often severe at the hip which is drawn into a position of flexion, adduction and external rotation; indeed apparent shortening of the leg may be the first complaint in osteoarthritis of the hip.

Swelling. There is normally but little swelling although effusion into the joint frequently follows over use or minor injury. Loose bodies *may* cause transient locking and other acute symptoms.

X-rays (Figs. 334 to 337). The characteristic changes, any one of which may be the first to appear, are narrowing of the joint space, the development of cyst-like spaces in the bone, and new bone formation.

Narrowing of the joint space, which is an indication of destruction of articular cartilage, usually begins at the summit of the joint. Often one part of the joint is more severely affected than the rest, for example at the knee where only one condyle may be involved.



Fig 337 Lateral X-ray of the hip showing advanced osteoarthritis Note the narrowing of the joint space, the cysts in both femoral head and ilium, and the new bone which has formed around the head which is still outlined beneath it.

Cyst-like spaces sometimes appear before there are any other radiologically demonstrable changes. This is not infrequently the case in early osteoarthritis of the hip when such a space is often present at the upper angle of the acetabulum (Fig. 334). The subchondral bone is increased in density and, in advanced disease, the structure of the cancellous bone is altered for some distance from the joint, becoming fluffy and rather dense, and containing numerous cysts.

Proliferation of bone at the articular margins first appears as an increase in the sharpness of the outline of the joint, or as an exaggeration in size of a normal protuberance such as the spine of the tibia. Osteophytes develop later; they may grow to a considerable size and entirely surround the joint.

Treatment

Osteoarthritis causes symptoms for two reasons. Firstly, there is the mechanical effect of the distorted joint. This does not of itself cause pain but it may restrict movement and cause deformity. It is amenable only to mechanical treatment. Secondly, there are the effects of the soft tissue changes which are responsible for most of the pain and some of the deformity.

The outstanding symptom calling for relief is pain and therefore it is the soft tissues that need most attention. Constitutional treatment is obviously of little value but help can often be given, at any rate for a time, by regulating the habits of the patient in such a way that the activity of the affected joints is adjusted to match their capacity. Local treatment is available in variety and many methods do help to relieve pain, but only temporarily. Unfortunately the pathological process, in most instances, is progressive and the time comes when a reasonable life is impossible in spite of conservative treatment. This is the time to consider operation, and there are few patients who cannot be helped by one or other of the alternative procedures.

The methods of treatment requiring consideration are:—

General Treatment.
- *Regimen.*
- *Occupation.*

Local Treatment.
- *Physiotherapy.*
- *Manipulation.*
- *Injection.*
- *Radiotherapy.*
- *Apparatus.*

Operation.
- *Arthroplasty.*
- *Arthrodesis.*
- *Joint denervation.*

General Treatment. Regimen. The management of a patient with osteoarthritis is *largely a matter of adjusting the regime to suit the* functional capacity. Exercise is of great importance because the joints can be kept free only by movement. If carefully planned and carried out, exercise may prevent deformity and maintain a useful range of painless movements, at any rate for a long time. The amount of exercise is discovered by trial; the optimum is the greatest amount that can be taken without paying for it in terms of increased pain and fatigue the same night or the next day. The intelligent patient is soon able to establish a regime that suits him, indeed he is often better able to do so than the doctor, but for other patients detailed guidance is necessary. Deliberate exercises are of value, even when an active life is being led, because they assist in maintaining movement in joints that might otherwise be protected

unconsciously; a table of exercises to be performed daily should be worked out in co-operation with the physiotherapist.

Osteoarthritis often occurs in the sthenic, florid type of heavy body build which tends to run to fat in later life, and it is desirable, particularly when weight-bearing joints are concerned, to reduce the weight to a reasonable level and then keep it constant.

Occupation. Patients with sedentary occupations are often able to adjust their lives to match their functional capacity. Manual workers, however, may have great difficulty in continuing at work and the time comes when it entails an excessive amount of exercise and causes definite harm. Unfortunately the age of the patient usually makes a complete change of occupation difficult, even if his intellectual attainments would permit it; with younger patients the problem needs careful consideration in co-operation with social worker and resettlement officer. *Retraining* should begin early and not be left until the disease is far advanced.

Local Treatment. Physiotherapy assists in relieving pain and maintaining movement. The triad heat, massage, and exercise are each used at some stage during the treatment of most patients. Short-wave diathermy is well tolerated and is often the best method of applying heat, but patients vary in their response and it may be necessary to try several methods to find out which is the most suitable. Hydrotherapy and exercise under water may be of value.

Manipulation under anaesthesia is occasionally of help in restoring movements but it must be carried out with care and without using excessive force or serious damage may be caused. It is more likely to be of value at an early stage and when the smaller joints, e.g. the tarsal joints, are affected. The ligaments of the larger joints like the hip cannot be stretched by manipulation, but skeletal traction continued for some weeks may be successful in decreasing deformity.

Injection into the joint of quite a wide variety of preparations has been tried but none has won general recognition.

Hydrocortisone given by intra-articular injection is under trial. It does at times seem to relieve pain due to synovial inflamation but its worth, even on a short-term basis, is not yet established.

Joint Acidification, as introduced by Grant Waugh, has a few advocates. It is effected by intra-articular injection of a preparation containing lactic acid. Injections are given at weekly intervals for six weeks and the course may be repeated several times with intervening periods of rest. A strict aseptic technique is essential; I have on several occasions seen suppurative arthritis following injections into the knee carried out in doctors' consulting-rooms. Although some patients seem to have benefited from this treatment, scientific assessment of the results is difficult; osteoarthritis follows a very slow course and a follow-up over a prolonged period is necessary. No convincing series has yet been published.

Radiotherapy gives a temporary amelioration of pain in perhaps half the patients, but the effect seldom lasts longer than a few months. It is often worth a trial, particularly in older people. With the younger age

group, the danger of repeated applications must not be forgotten; it is not unknown for patients who have been helped once to go to a second radiologist and conceal their history when the first has refused further treatment.

Apparatus. Assistance can sometimes be given by apparatus that restricts movement at a painful joint, or relieves it from bearing weight. A weight-relieving caliper may be helpful when the hip or knee is affected, but not many patients tolerate it indefinitely and most prefer operation when this alternative is offered. Movements of the spine may be restricted by a brace or corset (p. 76), and the elbows can be controlled by a suitable splint (Fig. 265, p. 353). For the wrist, arthrodesis is usually preferable to a permanent splint.

Operation. Surgery has an important place in the treatment of osteoarthritis. The chief indication is the relief of pain, but it is sometimes desirable for the correction of deformity and occasionally to restore movement. When modern facilities are available there is no need for any patient with monarticular disease to spend his life in continual pain because it can be relieved with some certainty by operation, often without interfering with his earning capacity. Even if several joints are involved, it is usually possible to make life tolerable by some combination of operations.

There are two principle procedures, arthroplasty and arthrodesis.

Arthroplasty is clearly the more desirable because it attempts to restore function to normal but, as yet, the applications are very restricted; indeed, it is only at the big toe joint that consistent results can be obtained. Arthroplasty of the hip has met with a measure of success, and is the subject of much research and experiment, but the results are still so uncertain that the operation should be advised only after full consideration of all the circumstances. It is very occasionally worth while at the knee, elbow and thumb.

Arthrodesis can be relied upon to relieve pain, and often it entails but little interference with general function. Many patients, not unnaturally, are loath to sacrifice movement, but they are more willing to accept this if the hazards of arthroplasty are explained honestly. Arthrodesis is usually the procedure of choice when only a single joint is involved, particularly in younger people. Bilateral ankylosis of the hips, knees or elbows is, however, a disability to be avoided at all costs and arthroplasty should be attempted, at any rate on one side. Bilateral ankylosis of other joints, for example the ankles and wrists, is not a great handicap. The problems concerned are discussed in the chapters dealing with individual joints.

Joint denervation. Interruption of the entire sensory nerve supply to a joint would relieve the pain with certainty, but since most joints receive branches from several nerves, it is seldom practicable to divide them all and the results are uncertain. The procedure is used most frequently at the hip (p. 185). Section of the pain tracts in the spinal cord has also been practised but the results are not encouraging.

NEUROPATHIC ARTHRITIS

(*Synonym*) Charcot's Disease

Neuropathic arthritis is a disease occurring when there is impairment of the sensory nerve supply of a joint. The commonest cause is tabes dorsalis, but it is also seen in syringomyelia, and occasionally in paraplegia of spinal or cerebral origin and after peripheral nerve injuries. The joints usually affected in order of frequency are the knee, hip, spine, foot, ankle and shoulder. Polyarthritis is uncommon.



FIG 338 Charcot's disease of the spine

An insensitive joint does not react in the ordinary way to disease or injury. This is partly because, in the absence of pain, there is no restraint of movement ; it is probable, however, that other factors are concerned although they are not yet understood. If trauma plus the absence of sensation were the only explanation, neuropathic arthritis should be much more common than it is, and also it should affect more than one joint in a limb.

The pathological changes resemble those of osteoarthritis taking place at high speed, as if seen on an accelerated kinematograph ; there is, however, more destruction of bone, and as a rule effusion is greater.

It is customary to divide neuropathic joints into two types : *atrophic* in which there is extensive destruction of articular cartilage and bone (Fig. 339), and *hypertrophic* in which new bone formation is on a massive scale, but pure types are unusual and it is more common for them to be mixed. In a typical example the joint is grossly disorganized, large areas of bone disappear entirely, and there is extensive formation of osteophytes (Fig. 175, p. 239). Occasionally osteophytes become detached in large numbers and the joint, when grasped, feels like a "bag of bones." In both types there is usually a large and persistent effusion into the joint which so stretches the capsule and ligaments that partial or complete dislocation readily takes place. A dry form without effusion also occurs but is less common.

The typical mode of onset is rapid swelling of the joint following a slight injury, such as a sprain. Deterioration is quick and within a few months the joint may be more or less completely destroyed ; the limb is

weak, the joint is unstable, perhaps flail, and frequently dislocated. Occasionally the course is more chronic: the effusion subsides and recurs at intervals, and the condition differs from osteoarthritis only in its comparative painlessness and in the extent of new bone formation. Clinical diagnosis can be made with some certainty when there is a painless arthritis with gross effusion in the presence of disease of the central or peripheral nervous systems.



FIG. 339. Charcot's disease of the shoulder Atrophic type with little new bone formation

Treatment

Protection for the joint should be provided as soon as the diagnosis is made, and without *waiting for the limb to become entirely useless, in the* hope that deformity will be prevented and bone destruction limited. A weight-relieving caliper may be supplied for the foot, knee or hip; the elbow can be protected by a leather corset. No satisfactory apparatus for the shoulder has been devised, but protection is less important than for a weight-bearing joint. Fluid should be aspirated, if necessary repeatedly, and a pressure bandage applied to prevent the ligaments being stretched

CHAPTER XIII

TUMOURS OF BONE

BENIGN TUMOURS OF BONE

CHONDROMA AND OSTEOMA

A CHONDROMA is a tumour, initially composed of cartilage, which may either project outwards from the bone to form an exostosis (*ecchondroma*), or grow inwards into the substance of the bone (*enchondroma*). A chondroma of either type can occur as an isolated phenomenon, or several of one type or of both types may be found in the same individual. Sometimes there is a familial history. Ecchondromata, even when single, are regarded by some authorities as a localized form of diaphysial aclasis, but although this may sometimes be so, there is not as a rule any other disturbance in the growth of the bones and it is probable that the two conditions are distinct (p. 497).

Exostoses

Ecchondromata are the commonest benign tumours of bone. When they ossify, as is usually the case, they are also known as *exostoses, ossifying chondromata* and *osteochondromata*. They commence to form early in life although diagnosis may be delayed until they are of sufficient size to attract attention. The usual site of origin is near to an epiphysial disc but it is uncertain if the cause is some minor disorder in the normal sequence of growth, or if the tumour is merely an exaggeration of a normal protuberance intended for the attachment of a muscle. Ossification usually occurs at the same speed and in the same manner as in the parent bone, and growth ceases at the same time as the general growth of the individual concerned.

The typical exostosis (Fig. 310) is situated near the end of a long bone, often around the knee; it is attached by a broad base and points away from the growing end of the bone. It is composed of ordinary cancellous and cortical bone which is structurally continuous with the parent bone, and it is capped with a layer of calcifying cartilage at which growth takes place.

Symptoms are entirely mechanical; if the tumour is large it forms a tender projection under the skin, and sometimes it interferes with neighbouring structures, e.g. nerves, muscles and joints. There is seldom greater discomfort than a mild ache, unless there happens to be pressure

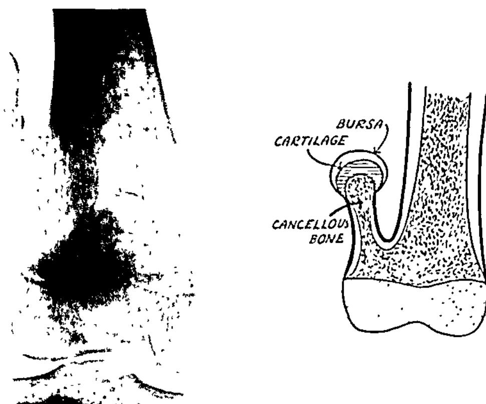


FIG 340 Exostosis of the lower end of the femur.

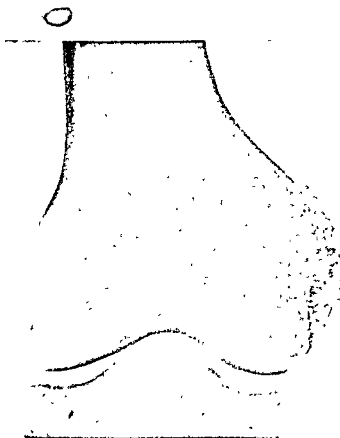


FIG. 341. Ossifying enchondroma in a young man complaining only of a lump at the inner side of the knee.

on a nerve. Some pathologists think that malignant changes occasionally take place in the cartilaginous cap which then assumes the characteristics of an osteosarcoma, but this is not certain.

An exostosis should be excised if its size or the symptoms warrant interference.

Enchondroma

Enchondromata, which may be single or multiple, develop within bone, and as they grow the bone is destroyed from within outwards, the cortex being reduced to a thin shell (Fig. 342). Occasionally the cortex is perforated and the tumour continues to grow outside the bone sometimes reaching a considerable size. Not infrequently it degenerates and liquifies leaving a cyst containing mucoid material, sometimes it ossifies completely or in part (Fig. 341), and it is thought that very occasionally sarcomatous changes occur. It is probable that enchondromata are ætiologically distinct from a similar condition occurring in dyschondroplasia (p. 501).



Fig 342 Enchondroma of the first metacarpal to which attention was drawn by a "spontaneous" fracture

The first sign of an enchondroma is usually swelling, but sometimes the bone fractures before anything abnormal is noticed. Pain is seldom prominent. Treatment is by excision of the cartilaginous mass together with its perichondrum, and if necessary, replacement by a bone graft.

Osteoma

This uncommon tumour, which is also known as an ivory exostosis, results from overgrowth of bone, as distinct from cartilage. It may be difficult to differentiate an osteoma from an ossifying enchondroma on clinical, histological or radiological grounds. It is sessile, not pedunculated, and is formed by deposition of lamellar bone.

Osteomata are usually found in connection with the bones of the skull, particularly the vault. They are of extreme hardness and occasionally grow to so great a size as to endanger life. The tumour may be found adhering like a limpet to the outer surface of the vault, or else it may originate in the frontal or sphenoidal sinuses, in the auditory meatus, in the antrum, or in the lower jaw, usually near the angle. When commencing in the frontal sinus it sometimes encroaches on the orbit.

FIBROUS DYSPLASIA

No lesions have given rise to greater confusion in terminology than those in which cysts and fibrous tissue are formed within bone. The original names were based on the macroscopic appearance, and with the development of histological technique the muddle became even greater because of wide variations in interpretation. The present tendency is to discard the old terms such as osteitis fibrosa and fibrocystic disease and include them all under the general heading of fibrous dysplasia.

The term fibrous dysplasia is not intended to convey a precise concept but it does emphasise the one feature all these conditions have in common—the replacement of bone by fibrous tissue which may contain areas of cystic degeneration. It does not give any idea as to the clinical behaviour of the lesions which have every gradation from a small and harmless "fibroma" to the most extensive changes in nearly every long bone in the body. A more precise formulation is unlikely on the basis of histology alone and it may have to wait until the etiology, which probably varies, is understood.

Fibrous dysplasia may be divided into [illegible] bone cysts, 2) monostotic fibrous dysplas[illegible] dysplasia.

Solitary bone cysts

This is the commonest form of fibrous dysplasia. The cysts are lined with fibrous tissue which, when young, often contains giant cells. This feature, together with others, has led some pathologists to relate cysts to osteoclastomata. Indeed, the histological resemblance may be so close that confusion is easy, but the course and prognosis are so very different that it is important to make the right diagnosis.

Cysts are seen chiefly during the second, third and fourth decades of life, and almost always in the shafts of the femur, the tibia or the humerus, although examples have been described in other long bones. The cyst starts near an epiphysis but during growth it is carried along the bone and it may be some distance down the shaft when first diagnosed. Cysts in the metacarpals and phalanges are usually of a different nature and are produced by degeneration of enchondromata.

[illegible] escape notice, although there [illegible], and usually a "spontaneous" fracture is the first indication of trouble. Radiologically the cyst has a smooth outline; it encroaches on the cortex which is therefore thin and may be slightly expanded (Fig. 343).

Treatment. The prognosis is excellent and quite simple procedures cause the cyst to heal—even a fracture may be sufficient—and the structure of the bone then returns to normal. When the first symptom is a fracture and the radiological appearance is that of a cyst, the limb may be splinted and progress observed by serial X-rays. But when some other symptom has drawn attention to the condition, the radiological diagnosis is less certain and then biopsy is usually desirable; the fibrous lining of the

cyst may be removed with a curette at the same time if the lesion appears to be benign.

Monostotic fibrous dysplasia

This is a rare condition in which the changes are limited to a single bone. It is probably a variant of the polyostotic form although the etiology may sometimes be different. The pathological appearance is, in general, similar to that described below. There are, however, some lesions which are both well localized and composed of mature fibrous tissue; they resemble ordinary fibromata closely. The process probably begins in childhood but, because of the relatively benign course, there are often no symptoms until later in life.

Any of the long bones can be affected but more often the ribs, upper end of femur and tibia, and also the facial bones and skull. Complaint may be made of pain and swelling, or the first indication may be a pathological fracture. X-rays (Fig. 344) show a localized, translucent area with a clear outline, sometimes irregular in shape and perhaps divided by thin partitions of bone which give a polycystic appearance. These features are not diagnostic and a biopsy is necessary.

There is a greater tendency to local recurrence after surgical removal than is the case with solitary cysts, but this is probably the best treatment. Radiotherapy is sometimes advised but the results are not certain and it is better avoided.

Polyostotic fibrous dysplasia

This is a true dysplasia of congenital origin; it must not be confused with the general skeletal changes of hyperparathyroidism (p. 488). A number of bones are involved, sometimes in one limb only, sometimes on one side of the body and occasionally on both sides; the skull is often affected as well.

The essential feature is the replacement of the bony structure by a grey coloured mass of fibrous tissue. The more newly formed zones are vascular and contain many cells of fibroblastic type. Some areas are rich in reticulo-endothelial cells and show evidence of osteoid and calcified trabeculæ. The older zones contain cystic cavities surrounded by dense whorls of fibrous tissue.

Diagnosis is usually made early, the child coming under observation because of increasing deformity or pathological fracture. X-rays show the cortex of the affected bones to be greatly thinned and often expanded, and the inner surface may be scalloped (Fig. 345). The central cavity has a homogeneous appearance said to resemble frosted glass. The bones of the face and skull may be greatly thickened.

Treatment is without effect but no fresh lesions appear after growth has ceased; the length of life is not reduced.

Albright's syndrome is a special form of polyostotic fibrous dysplasia occurring nearly always in females and associated with pigmentation of the skin, sexual precocity and sometimes hyperthyroidism.



Fig. 343 Solitary cyst of the humerus in a girl six years of age. It had not recurred fifteen years after resection

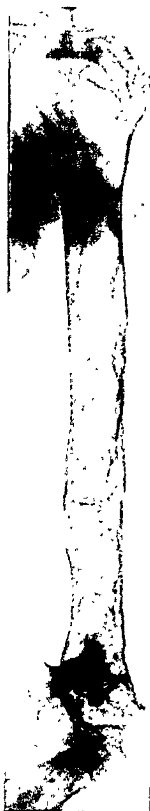


Fig. 345. Polyostotic fibrous dysplasia.



Fig. 344 Monostotic fibrous dysplasia that has recurred after curettage (by courtesy of Mr. St. J. D. Buxton).

cyst may be removed with a curette at the same time if the lesion appears to be benign.

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Fig. 346 Osteoclastoma of the upper end of the tibia It was treated by local resection but recurred and finally was controlled by radiotherapy There was no recurrence thirteen years later



Fig. 347. Oldstanding osteoclastoma at the lower end of the tibia treated by irradiation Malignant changes eventually took place and the limb was amputated

cavity is large, it may require filling with cancellous chips and strengthening with a cortical bone graft.

Resection of the affected length of bone is necessary only occasionally when the tumour is very large and the joint grossly disorganized.

Radiotherapy. This form of treatment readily causes a solitary cyst to heal but the effect on osteoclastomata is less certain. The author's view is that the best approach, when the site permits it, is to remove the tumour locally and follow this at once with radiotherapy ; a bone graft may, when necessary, be added later.

OSTEOCLASTOMA

(*Synonyms*) Giant-celled Tumour, Myeloid Sarcoma

Osteoclastomata are tumours, usually benign, which occur at the end of long bones in young adults. They have a close histological resemblance to solitary bone cysts and the two are often confused. There is uncertainty as to both the age and the site at which osteoclastomata start. Some think growth begins in the metaphysis and invades the epiphysis after the epiphysial disc has closed, whilst others believe it starts in the epiphysis. Whichever is the case, there is often extensive involvement of the epiphysis at the time of diagnosis.

Macroscopically the typical tumour has a patchy yellow and red appearance from old hæmorrhage, and it is soft and friable to touch; in the earlier stages it is usually trabeculated. Microscopically it consists of large multinucleate giant cells embedded in masses of small spindle cells. Occasionally, as a rule at the lower end of the radius, the tumour is relatively avascular—the so-called "white myeloma." Sarcomatous changes are not uncommon in tumours that have been present for some time. Occasionally they give rise to metastases, usually in the lungs, which retain the histological appearance of an osteoclastoma.

The bones principally affected are the upper end of the tibia, the lower end of the femur and the lower end of the radius. The growing ends of all the other long bones are occasionally involved, and also the pelvis, the vertebræ, the carpal and tarsal bones, and the mandible.

The symptoms are pain, swelling, restriction of movement, and sometimes fracture. Not infrequently the first symptoms occur after a minor injury causing hæmorrhage into the tumour. At a later stage, when the bone supporting the joint surface has been destroyed, the joint collapses and there is deformity and loss of function.

The radiological appearance varies with the stage of development (Figs. 346 and 347). At first the lesion, which is placed asymmetrically in the bone, is confined to the metaphysis, but later the epiphysis is encroached upon. Both cancellous and cortical bone are destroyed leaving a smooth, lobulated outline. The cortex may be reduced to a mere shell and is often expanded, but there is no periosteal reaction.

Treatment. The tumour is less easily controlled than is sometimes believed. Re-examination of a large series collected from several centres has given reason to doubt the diagnosis of many of the lesions that responded well to treatment. The true osteoclastoma has a strong tendency to recur locally whatever the treatment. Sarcomatous changes are not uncommon in large, old-standing tumours, particularly after irradiation.

The choice of treatment lies between local removal of the tumour, resection of the affected length of bone, and radiotherapy.

Local Removal, when practicable, is regarded by many surgeons as the procedure of choice. It is, however, essential to remove the entire tumour and all its covering membrane, or it will recur. If the residual

MALIGNANT TUMOURS IN BONE

The classification of malignant tumours in bone has not yet reached the stage of accuracy achieved with malignant disease of other structures. Classifications relating them to the supposed tissues of origin and to benign tumours of bone are attractively simple, but fallacious. There is little to be gained by following the elaborate nomenclature that is sometimes introduced and the simplest possible terminology is used here :—

Primary Skeletal Tumours.
- *Osteosarcoma.*
- *Chondrosarcoma.*
- *Fibrosarcoma.*

Non-Skeletal Tumours.
- *Myeloma.*
- *Leukæmia.*
- *Hodgkin's disease.*
- *Endothelioma (Ewing's tumour)*
- *Histiocytosis.*

Metastatic Carcinoma.

Diagnosis

The diagnosis of a malignant tumour is always a responsible task, not only because failure to recognize its nature may deprive the patient of his only chance of life, but also because the opposite mistake may result in an unnecessarily mutilating operation. Malignant tumours in bone are particularly difficult to identify; no single investigation can be relied upon and it is essential to consider together all the clinical, radiological and laboratory evidence that can be marshalled.

Clinical Findings. Pain, tenderness and swelling are the outstanding clinical features; they may have no positive diagnostic significance, but the unexplained presence of any one of them is an indication for immediate investigation. The length of history should be compatible with the type of tumour under consideration.

Blood Count. The white cell count seldom exceeds 15,000 with tumours in bone. Persistent eosinophilia may accompany parasitic cysts.

Blood Chemistry. This may give an indication of decalcification due to causes other than tumours. An excess of "acid" phosphatase is often present in the serum when there are prostatic metastases, and Bence-Jones protein is found in the urine of many patients with myelomatosis.

Wassermann Reaction. A positive reaction, although suggestive, does not prove that the bony changes are due to syphilis because a tumour can develop equally well in a syphilitic subject.

X-rays. The corresponding site in the opposite limb should be X-rayed for comparison when looking for early changes, and if any doubt remains, the examination is repeated after a few weeks. Tangential views in several planes are helpful in detecting early erosion of the cortex. The whole skeleton must be examined for the presence of other tumours, and the

OSTEOID OSTEOMA

This curious tumour was first described by H. L. Jaffe in 1935 and is usually accepted, although with some hesitation, as a benign neoplasm. The lesion consists of a small radiolucent mass about a quarter of an inch in diameter surrounded by a zone of sclerosed bone ; it contains a central nidus composed of osteoid tissue lying in a highly vascular osteoblastic stroma.

Men are affected more often than women, and nearly always during adolescence or early adult life ; it is rare after thirty. Any bone may be involved but most often the femur or tibia.



FIG. 348 Osteoid osteoma at the base of the neck of the femur.

Pain is the only symptom of importance and it may be severe. It is not accurately localized and is usually worse at night. A characteristic feature is the relief given by aspirin. Examination shows well localized tenderness, and perhaps some thickening of the bone. Radiologically, there is a small translucent area surrounded by a zone of sclerosis and usually containing a dark speck resembling a sequestrum ; there is often a periosteal reaction (Fig. 348). The lesion may be very difficult to demonstrate in the vertebræ and the small bones of the hands and feet, and patients with lesions at these sites are only too often regarded as "neurotics".

The natural history must be towards spontaneous remission because the complaint is not encountered in older people. Surgical excision of the nidus is followed by immediate relief of pain and therefore is welcomed by most.

As the tumour grows it erodes the cortex of the bone from either the outer or inner surface according to the site of origin. It may spread along the medulla, and also under the periosteum lifting it up to form a mass beneath it, and it may penetrate the periosteum and infiltrate the surrounding soft tissues. The exact behaviour of an individual tumour depends on the balance between its natural tendency to grow and destroy, and the resistance of the body. Dissemination is by metastasis usually to the lungs, but occasionally to other bones or to the regional lymphatic glands.

Clinical Features

Some 60 per cent of all primary osteosarcomata occur at the upper end of the tibia or lower end of the femur, and next in frequency is the upper end of the humerus; the other long bones are less often involved, and the flat bones only very occasionally. The incidence is greatest during the second decade of life, and considerably less during the third decade; few cases occur after forty years of age, except in association with other conditions such as Paget's disease, or a longstanding chondroma, chondrosarcoma or osteoclastoma.

The characteristic symptoms are pain and swelling.

Pain. This is often the first indication that anything is amiss, and it is usually pain that brings the patient to consult his doctor. Deep pain that is continuous and well localised is always suspicious. A patient under twenty years of age with pain in the region of the knee of sufficient severity to make him seek medical advice, and with tenderness on pressure over the bone, must have his complaint investigated fully and without delay.

Swelling. This follows pain after an interval of weeks or months. The size of the swelling varies very much with the particular tumour and often it seems as if it were larger than the X-rays suggest it should be. Sometimes swelling can be detected only on careful palpation, but sometimes it is considerable, the skin is stretched tightly over it, and the superficial veins are dilated. The tumour is usually firm and has an elastic, rubbery feeling, but when very large it may be soft and boggy.

Stiffness of the neighbouring joint, and also a limp, may develop later, but these are not constant findings. With osteolytic growths spontaneous fractures are common and may be the first symptom. The lymph glands draining the region of the tumour are sometimes enlarged. There may be a moderate leukocytosis which rarely exceeds 10-15,000, and sometimes there is a slight fever.

X-rays (Figs. 349 and 350). Some malignant tumours of bone have a typical radiological appearance and it is on these that the classical descriptions are based, but so many growths are atypical that no man can be dogmatic on this subject. Sometimes it is difficult enough to say if a tumour is malignant or benign, or, indeed, if the bony changes are due to new growth and are not the result of inflammation; to identify with certainty the type of growth that is present is often impossible.

The characteristic features are (a) destruction of bone accompanied by irregular new bone formation, and (b) a lack of definition, or outline, to the

chest should invariably be X-rayed to exclude the presence of secondar deposits and tuberculosis.

Biopsy. It has often been suggested that surgical removal of a portio of a tumour may disseminate the growth, but it is now agreed by almo all authorities that there is no evidence that this is so. Biopsy is a mo important diagnostic procedure and should be performed in nearly ever instance. It is also of assistance in assessing the probable degree of radi sensitivity of the tumour, and therefore the best method of treatment.

When performing a biopsy, a wide exposure is necessary to enab careful selection of the portion for removal; this should be large in siz of recent development, and include some healthy bone. A tourniqu should be used, but an Esmarch's bandage must not be applied over th site of the tumour. "Punch" biopsy provides a smaller amount of materi and is apt to fail just when help is most needed; moreover it has bee suggested that it increases the risk of dissemination because the small hol thus made in the cortex is rapidly sealed by clot and the tension rises i the traumatized area.

OSTEOSARCOMA

Osteosarcomata form the largest and most varied group of malignan tumours of bone. They develop for the most part in connection wit persisting embryonic connective tissue, and since this retains the abilit to differentiate into the component parts of bone to which it normall gives rise, the histological appearances are very diverse. The type of cel the stroma in which the cells are embedded, and the amount of cartilage an of bone in the tumour vary greatly and the histology cannot always b correlated satisfactorily with either the radiological appearances or th clinical course (Scarff). The greater one's experience with this class c tumour, the more uncertain does one become in the interpretation of th pathological and radiological findings, and the more cautious is th prognosis given.

The types of cells commonly found in osteosarcoma are spindle shaped fibroblasts, small round cells and large polygonal cells; they ar embedded in a stroma that may be abundant or scanty, and may consis of myxomatous, cartilaginous, osteoid or bony tissue. No tumour is com posed entirely of one type of cell or stroma, and although one type ma predominate, it is often possible to find typical areas of every type in single tumour. Little is to be gained, therefore, by naming the tumou after the predominating tissue, e.g. myxosarcoma, liposarcoma, etc., no is there any advantage in calling it periosteal or endosteal because the sit of origin is frequently indeterminate. A distinction can usefully be made however, between *osteoplastic* tumours which form bone more quickly tha they destroy it, and *osteolytic* tumours which destroy bone more rapidl than it is formed.

The majority of tumours occur at the ends of long bones, usually at the diaphysial side of the epiphysial disc or in the subperiosteal region nea one of the bony protuberances into which the larger muscles are inserted.

Amputation. This is more frequently practised in the lower limb, partly because there are few, if any, recorded cures following amputation of the upper limb, and partly because lower limb amputation causes less interference with function. The site of amputation should be the next site of election above the upper limit of the tumour. There is no need to amputate higher because metastases occur in the lungs and rarely in the proximal part of the limb.

Irradiation. Many types of tumour are sensitive to X-rays or radium but the number of patients cured does not appear to be greater than by other methods. The general rule is that the greater the cellular differentiation, the poorer the response, but in practice there are many exceptions. When cure by any method is out of the question, it may be possible to control the local growth of a tumour by irradiation, and to prevent the dreadful pain so often associated with involvement of the brachial plexus and other nerves.

A combination of radiotherapy and amputation is practised at a few clinics. The tumour is first irradiated very heavily and the limb is amputated a few months later. There is some circumstantial evidence that the frequency of metastasis is slightly reduced by this method.

CHONDROSARCOMA

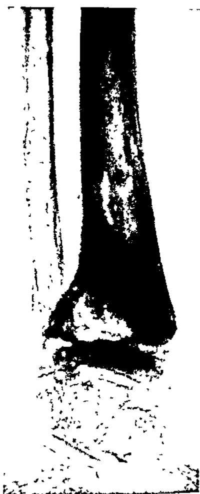
(*Synonym*) Infiltrating chondroma

This tumour, which is relatively common, has a clinical course that is very different from osteosarcoma. It commences in an apparently benign form and may persist as such for very many years, even half a century, during which time it often grows to a great size. In many instances, however, it ultimately takes on the characteristics of a highly malignant osteosarcoma and is rapidly fatal. Occasionally a chondroma of the pelvis gives rise to metastases in the lungs which have the same nature as the primary tumour even though there is no other evidence of malignancy.

The tumour is arranged in a lobular manner and usually consists of well-formed cartilage with areas of cystic and hæmorrhagic degeneration ; irregular calcification causing a mottled radiological appearance is common. It grows outwards pushing the soft tissues away from it without invading them ; it also spreads along the medullary cavity of the bone eroding the cortex from within, a feature which may be regarded as evidence of local malignancy although metastases seldom occur at this stage.

Clinical Features. The usual age for diagnosis is during the third, fourth and fifth decades ; this is later than other tumours because during the benign stage it may remain undetected for many years. The common locations are the diaphysial regions of both upper and lower ends of the femur, the upper end of the humerus and the pelvis. The site of origin in the long bones is usually one of the bony protuberances to which the long muscles are attached, but in the pelvis the usual position is near the epiphysis of the crest of the ilium, or near one of the points where the component bones of the pelvis are joined together.





Above FIG 349 Osteosarcoma (osteolytic)

Right FIG 350 Osteosarcoma (osteoplastic)

area of the growth. Osteolytic tumours usually commence centrally and spread asymmetrically; the cortex is destroyed, the periosteum is raised and new bone is often formed beneath it. In osteoplastic tumours dense new bone is formed which destroys the normal trabeculæ and obliterates the distinction between medulla and cortex; spicules of new bone radiate out from the shaft, raising the periosteum and giving rise to the classical "sun-ray" appearance. Growths commencing subperiosteally erode the cortex from without and may give it a mottled or stippled appearance due to alternating patches of bone destruction and bone formation. A large soft-tissue shadow, even when it has a definite outline, is suggestive of malignant disease provided it is accompanied by erosion of bone.

Treatment

The prognosis is extremely bad, the duration of life seldom being more than a year or two in individuals under twenty, and only a few months in young children. A small number of patients with undoubted osteosarcoma have, however, been cured by amputation, by resection of the affected bone, by irradiation, and by a combination of these procedures. The choice of treatment depends to some extent on the site and the nature of the growth.

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The only clinical sign may be swelling and the patient is often unaware of the existence of the tumour until it is large enough to be obvious. The size may remain stationary for years, or it may slowly increase. Sometimes there is a history of vague pain. The onset of malignancy is difficult to determine but it is suggestive when a tumour that has been present for some time rapidly increases in size and begins to hurt. Biopsy is an essential diagnostic step but it will only establish malignancy if the right portion of the tumour is removed.

X-rays. The appearances are variable. Sometimes the tumour closely resembles an osteoclastoma, but more often it is of massive size and stippled with areas of calcification (Fig. 351). The outline is well defined and often lobulated, but definition is lost after the tumour has spread outside the bone.



FIG. 351 Chondrosarcoma arising from the pubis close to the ilio-pubic junction It was excised together with the part of the bone to which it was attached

Treatment. Because of the risk that it will later become frankly malignant, a chondrosarcoma should be excised, or the limb amputated. It is essential to removal the entire tumour or malignant degeneration may be precipitated in the remaining portion. A difficult decision has to be made when ablation of the neoplasm involves a crippling procedure. The tumour is highly differentiated and does not respond favourably to irradiation.

FIBROSARCOMA

Fibrosarcoma is a fibroblastic tumour which arises within bone and infiltrates and destroys it. The site of origin may be medullary or periosteal but, since there is no difference in the histological appearance or clinical behaviour, the distinction is not of great value. The prognosis is better than with osteosarcoma and more than half the patients treated radically survive at least five years.

The histological picture is essentially the same as fibrosarcoma arising elsewhere in the body. The predominant cells may be primitive oat-shaped cells, spindle cells or fibroblasts according to the degree of differentiation; the more primitive the cell type, the greater the degree of malignancy, and the worse the prognosis.

There is a small group of rare but closely related tumours composed of muscle elements (*rhabdomyosarcoma*), or nerve elements (*neurogenic sarcoma*), which also invades bone. Both are very similar to fibrosarcoma in behaviour, but they are generally of greater malignancy and permanent cure is almost unknown with any form of treatment.



FIG. 352 Medullary fibrosarcoma.

Fibrosarcoma has a predilection for the lower end of the femur and upper end of the tibia but it may occur anywhere in the shafts of the long bones and sometimes in the ribs. It affects chiefly young adults, and although no age is immune, the maximum incidence is during the fourth decade. Metastases occur in the lungs and quite often in the regional lymph glands.

X-rays (Fig. 352). The early appearance varies with the site of origin. Periosteal tumours show a large, rather dense soft tissue shadow; they may cause only a saucer-shaped depression in the bone, or they may invade and destroy it. Medullary tumours erode the cortex from within and are notable chiefly for the absence of a periosteal reaction.

Treatment. Radiotherapy alone is seldom successful and the best results have been obtained by radical surgery, or by a combination of surgery and irradiation.

MYELOMATOSIS

(*Synonyms*) Kahler's Disease, Myeloid Sarcoma

This condition is not a true tumour of bone but a disseminated malignant disease which usually, although not invariably, involves bone. The common type consists of plasma cells (*plasmocytoma*), but tumours composed of myelocytes (*myelocytoma*) and lymphocytes (*lymphocytoma*) occur very occasionally, and tumours of erythroblasts (*erythroblastoma*) have been described. The source of the cells is not known, nor if the malignant process commences at a single site or has a multifocal origin. The following description refers only to the plasma cell type but the others have a similar clinical course.

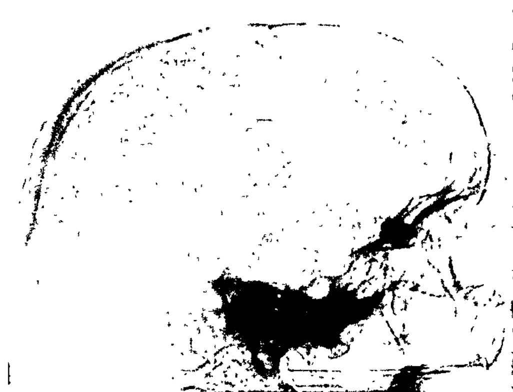


FIG 353 Myelomatosis with multiple deposits in the skull

The disease is one of adult life, usually late middle age, and males are affected more than females. In the typical form there are multiple deposits in the skeleton at the time of diagnosis. The bones chiefly affected are the ribs, vertebræ, sternum and skull, but the femora, pelvis, humerus, and indeed any other bone, may be involved. The tumours commence in the bone marrow and do not as a rule grow to a size exceeding an inch in diameter, but sometimes the affected bones are diffusely infiltrated and their internal architecture is completely destroyed.

The tumour is occasionally solitary at the onset but subsequently spreads to other bones, and very rarely it remains solitary without further dissemination. Spread to the soft tissues, particularly the liver and spleen,

is common in the terminal stages, and the bloodstream may be invaded by plasma cells (*plasma cell leukaemia*).

A peculiarity of the multifocal form of the disease is the excretion of Bence-Jones protein in the urine of rather more than half the cases (it is also present on rare occasions in a variety of other conditions). This protein precipitates on warming to 50°C., disappears on boiling, but re-appears on cooling again. The serum globulin is often raised, and the serum calcium may be increased when rapid destruction of bone is in progress. In some patients the kidneys are damaged by blockage of the tubules, probably by Bence-Jones protein, and this causes nitrogen retention.

Primary extra-osseous tumours are uncommon, but they do occur. The usual sites are the upper air passages, the mouth and the larynx, and very rarely elsewhere. The course may be comparatively benign, but some tumours are locally malignant, whilst others become disseminated and give rise to secondary involvement of the skeleton.

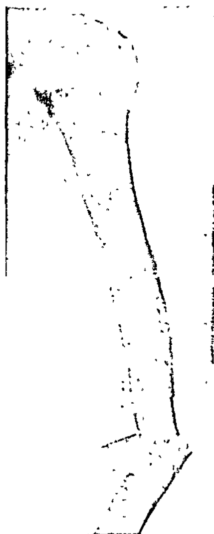


FIG 354 Diffuse myelomatosis.

Diagnosis. Attention to the presence of the disease is usually attracted by pain, or by the occurrence of a "spontaneous" fracture which is an early and usual symptom. Since the vertebræ are often involved, pain in the back is a common initial complaint. The typical X-ray shows multiple, roughly circular, areas of *rarefaction with sharply* defined margins (Fig. 353); occasionally there is diffuse infiltration and gross destruction of both cortex and medulla of the affected bones (Fig. 354).

Diagnosis is simplified when there is Bence-Jones protein in the urine, but histological examination is often necessary. Sternal puncture is of value because the sternal marrow is frequently involved.

Treatment. The generalized affection, although sometimes fulminating, follows a rather slow course lasting a couple of years and is always fatal in the end. Individual tumours respond well to radiotherapy but the general course is not affected. Pain in the bones may be alleviated by irradiation, and fractures often unite after treatment; root pain due to vertebral collapse is, however, a distressing feature that is difficult to relieve. The prognosis with solitary tumours is a little better; it may be possible by irradiation to control the local growth and it is often

her foci appear.

LEUKÆMIA

Bone destruction occasionally accompanies both lymphatic and myelogenous types of leukæmia. The characteristic radiological picture shows osteoporosis and small, punched-out areas of cortical erosion. In rare instances greenish tumours (*choloroma*) are formed in the skull, vertebræ, sternum or long bones.

HODGKIN'S DISEASE

Invasion of bone by Hodgkin's tissue not infrequently occurs in the later stages of this disease. The cortex of the bone may be invaded by direct extension from the soft tissues, or there may be a medullary focus which infiltrates and destroys the bone from within (Fig. 355). The local affection of bone can be controlled by radiotherapy.



FIG 355. Hodgkin's disease with involvement of the femur.



FIG. 356. Ewing's tumour (by courtesy of Mr H. J. Seddon).

ENDOTHELIOMA

(*Synonym*). Ewing's tumour

There is a group of uncommon tumours the origin and interrelationship of which is still in dispute, but there is reason to think they arise in the supporting structures of the bone marrow. They are not true tumours of bone but they invade bone. The group includes *endothelioma* (Ewing's tumour), *reticulum cell sarcoma* and *angioendothelioma*. It is exemplified by Ewing's tumour, which is the least rare, and this is the only one that will be described here.

Ewing's tumour is primarily a condition of childhood and adolescence ; 50 per cent of cases occur before the age of twenty, 80 per cent before thirty, and it is exceptional after forty (Kolodny). Males are affected twice as frequently as females. The usual site is the shaft of a long bone, but any bone may be affected. The prognosis is very bad and metastases occur quickly in the lungs, in the lymphatic glands and in other bones.

Clinical Features. The early symptoms are pain and pyrexia occurring in intermittent attacks. There is a strong resemblance to an acute infection, so much so that osteomyelitis is nearly always the first diagnosis to be made. At a later stage there is a swelling which tends to vary in size from time to time, and usually marked tenderness. There is often some leukocytosis but the white cell count is seldom over 15,000.

X-rays (Fig. 350). The earliest changes are in the shaft of the bone ; the cortex becomes thickened, expanded and altered in structure, and new periosteal bone is laid down. Successive depositions of periosteal bone may cause a typical "onion skin" appearance in which there are several concentric laminae of new bone around the shaft. At a later stage the tumour extends along the bone destroying both cortex and medulla.

Treatment. Ewing's tumour is *highly radiosensitive but although the* local condition is improved, metastases are not prevented. Amputation gives the best survival time but few patients have lived longer than three years.

HISTIOCYTOSIS

(*Synonyms*) Reticulo-endotheliosis, Lipoid Granulomatosis, Xanthomatosis

The group of affections included under this heading, all of them rare, are widely accepted as being closely related even though little is known of their etiology. The common feature is the appearance in the skeleton of [illegible] This tissue consists of pro- [illegible] which have the form of histiocytes. Sometimes the histiocytes are enlarged and contain precipitated cholesterol esters (or other lipoids) which give a characteristic appearance that has earned them the name of "foam cells" ; sometimes the granuloma also contains large numbers of eosinophils.

The distribution varies and it may be only one bone, or perhaps several, that contain well-defined granulomata. The cranial bones are

involved in most types but typical lesions occur in other bones as well. In some forms deposits in the viscera and skin are a major feature.

The symptoms depend on the distribution of the lesions. Spontaneous fractures are common when the long bones are affected. Radiological diagnosis should be confirmed by biopsy, but a recent lesion must be selected for examination because the lipoid disappears after a time leaving only fibrous tissue.

Hand-Schüller-Christian Disease. This condition, which is less uncommon than some, usually appears during childhood although it has been reported in adults. There are multiple granulomatous deposits in the skull and other bones occurring in association with signs of pituitary dysfunction such as diabetes insipidus or infantilism. The lesions contain



FIG. 357. Hand-Schuller-Christian disease (by courtesy of Prof B G. Windeyer).

histiocytes and other reticulo-endothelial cells, many of the former being enlarged by cholesterol esters to become "foam cells".

Radiotherapy often causes individual lesions to heal but there may be local recurrence or visceral involvement leading to a fatal termination.

Letterer-Siwe Disease is a very rare disorder which is considered by Fairbank to be an acute form of Hand-Schüller-Christian disease, but without cholesterol deposits in the histiocytes. It affects infants, both soft tissues and bones being involved, and is rapidly fatal.

Eosinophilic Granuloma. This disease may present with solitary or multiple lesions. It usually affects young people, mostly males, but it can occur at any age. Any bone may be involved but the soft tissues are seldom affected. The granuloma, which has the radiological appearance of a well-defined, translucent cyst, contains histiocytes without cholesterol deposits

and a large number of eosinophils. There is usually a satisfactory response to radiotherapy.

Gaucher's Disease, which is perhaps the least uncommon of the group, is often familial but seldom hereditary. It commences during childhood but the onset of symptoms may be delayed for many years. The essential feature is the deposition of kerasin, a phosphorus-free lipoid, in the histiocytes of the spleen, liver, lymph glands and bone marrow ("Gaucher's cells"). Slowly progressive enlargement of the spleen and liver are nearly constant features. The disease commences during the first three decades of life and usually runs a very slow course extending over many years until death occurs from intercurrent disease; occasionally the onset is rapid and the course acute.

The characteristic clinical feature is enlargement of the spleen which may reach extreme proportions. As a rule the liver is enlarged also, and frequently there is pigmentation of the skin and conjunctivæ. There are extensive changes in bone marrow caused by infiltration with "Gaucher's cells"; the lower end of the femur is affected more frequently than other bones.

Radiologically the bone is slightly enlarged, the trabecular structure of the cancellous bone is lost and it acquires a moth-eaten appearance; the inner surface of the cortex is eroded, and new bone is deposited under the periosteum (Fig. 358). The diagnosis can usually be made by the identification of "Gaucher's cells" in material obtained by sternal puncture.



FIG 358 Gaucher's disease (by courtesy of Sir Reginald Watson-Jones).

The course is very slow, and although removal of the spleen is followed by temporary improvement, the disease is always fatal.

Niemann-Pick Disease is extremely rare and affects almost exclusively female Jewish infants. Large quantities of a cholesterol compound are deposited in histiocytes throughout the body with a rapidly fatal result.

Gargoylism. This is a form of chondro-osteo-dystrophy which has some resemblance to Morquio's disease. Fairbank* has suggested that it may belong to the *group of histiocytoses* because lipoid deposits have been found in the reticulo-endothelial system. It is characterized by a heavy, ugly facies, corneal opacities, mental deficiency, kyphosis and enlargement of the liver and spleen. There is no treatment and few of the children survive to adult age.

* Sir Thomas Fairbank. *An Atlas of General Affections of the Skeleton.* E. & S Livingstone Ltd. 1951

METASTATIC CARCINOMA

Every type of epithelial tumour may give rise to skeletal metastases, but some do so with relatively greater frequency than others either because tumours have a varying affinity for bone, or because the resistance of bone to invasion varies with the type of tumour. Geschickter and Copeland give the following figures :—

	Number of cases	Number with osseous metastases	Per cent
Carcinoma of thyroid	15	6	40
" " kidney	63	22	35
" " lung*	24	4	17
" " prostate	1040	134	13
" " breast	1914	100	5
" " female genital organs ..	147	7	5
" " gastro-intestinal tract ..	1034	11	1
" " other sites	—	50	—
Total	—	334	—

The commonest secondary deposits to be found in bone do not, however, come from the thyroid and kidney because of the comparative infrequency of these tumours, but from the prostate, breast and lung in which malignant growths occur so often. The site of origin of the 334 metastases in bone listed above is :—

Prostate	134	=	40 per cent
Breast	100	=	30 per cent
Kidney	22	=	7 per cent
Gastro-intestinal tract	11	=	3 per cent
Female genital organs	7	=	2 per cent
Thyroid	6	=	2 per cent
Lung*	4	=	1 per cent
Other sites	50	=	15 per cent

The frequency with which different bones are involved also varies slightly with the origin of the tumour. For the breast it is spine, pelvis, femur, ribs, and cranial bones in that order; the prostate has a similar order but with a greater proportion in the pelvis and the lumbar and sacral vertebræ, and with renal metastases the incidence in the humerus is about equal to that in the femur.

Clinical Features

The appearance of a secondary deposit may be the first intimation of malignant disease, especially of the kidney, but usually the presence of a primary tumour is already known to both patient and doctor. Many patients, whether the primary tumour has been treated or not, are so

* The increasing incidence of bronchial carcinoma has made bony metastases from this source relatively more common but no recent figures are available.

earful of recurrence that they report any trivial pain at once, but others annot admit even to themselves the possibility of such a happening and onceal the advent of new symptoms until life has become intolerable.

The symptoms vary with the bone affected and the nature of the umour. Osteolytic deposits tend to cause more trouble than osteoplastic ecause the destruction of bone makes it liable to collapse or to fracture. Osteoplastic deposits may only be discovered during routine radiological xamination, and it often happens that for a long time they cause few, if ny, symptoms.

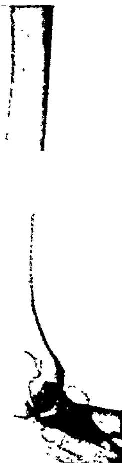


FIG 359 Osteolytic metastasis from a carcinoma of the breast (see also Fig 96, p 139)



FIG 360 Osteoplastic metastasis from a carcinoma of the prostate.

Deposits in the spine, the commonest site, may at first cause only slight and fleeting pain, or the earliest sign may be the development of deformity consequent on vertebral collapse. Later the pain becomes more serious, and should the nerve roots be encroached upon either by direct spread of the growth or by pressure of the collapsed spine, it may become one of the most intolerable and intractible pains that mankind is called upon to suffer. The first evidence of a deposit in a long bone is sometimes pain, and sometimes a "spontaneous" fracture. Headache is a characteristic symptom of cranial deposits.

Carcinoma of the prostate may give rise to secondary deposits before a prostatic tumour can be detected clinically; indeed malignant changes in the gland are often discovered only after it has been removed and examined histologically. Skeletal metastases are frequently osteoplastic and cause an increase in both the density and the size of the bone. When there is very extensive dissemination sufficient bone marrow may be destroyed to produce a severe secondary anæmia. The differential diagnosis from Paget's disease, which may be difficult on radiological grounds alone, is facilitated on those occasions when there is an excess of "acid" phosphatase in the blood serum.

X-rays. In osteolytic tumours the outstanding feature is destruction of bone (Fig. 359). The initial deposit is often central and it gradually spreads eroding and destroying the cortex; there is seldom much periosteal reaction. There may be but a single bony lesion, or there may be deposits in several bones (the entire skeleton should always be examined), and sometimes there are multiple foci riddling the bones as if with myelomatosis. In osteoplastic tumours bone formation proceeds more rapidly than bone destruction and there are areas of increased density of amorphous structure. (Fig. 360). Osteolytic and osteoplastic areas may occur in different parts of the same bone at the same time.

Treatment

The response to irradiation is, in general, similar to that of the primary tumour. As a rule any particular metastasis can be caused to regress and the bone re-ossifies, but sooner or later other metastases appear in bone and elsewhere, and they cannot be controlled indefinitely—life is prolonged, but not saved. Pain of a major character due to nerve involvement can often be alleviated by irradiation, but occasionally it is necessary to resort to division of the spino-thalamic tract and other operative procedures.

A pathological fracture in the lower limb can make the remainder of the patient's life so miserable that any alternative is a boon. There need be no hesitation before advising internal fixation of the fracture with a Küntscher nail, a nail-plate or whatever may be appropriate either before or after irradiation.

Prostate. Metastases behave similarly to the primary tumour when treated with stilboestrol. They usually regress and may be kept in control, often for years, if the daily maintainance dose is continued indefinitely. Radiotherapy may be of help with specially large or resistant deposits.

CHAPTER XIV

DISEASES AND CONGENITAL DEFECTS OF BONE

METABOLIC AND OTHER DISEASES AFFECTING BONE

AVITAMINOSIS D

A SUFFICIENCY of vitamin D is essential to the normal metabolism of bone. Bone is not a static material but is subject to perpetual change and throughout life there is a constant process of bone destruction balanced by new bone formation. In the absence of vitamin D bone formation is interfered with because the newly formed osteoid tissue is unable to calcify properly. The result of this is twofold: developed bone gradually becomes softer because when it is broken down in the ordinary course of metabolism it is replaced by incompletely calcified osteoid tissue; and in children osteoid tissue formed at the growth discs fails to calcify fully. In avitaminosis D occurring in children, therefore, both developed bone and the growth discs are affected, the condition then being known as rickets; in adults only developed bone is involved and it is called osteomalacia.

Rickets

Rickets is a disease occurring only before the epiphyses have closed and the principal changes are at the growth discs where the newly formed osteoid tissue fails to calcify. Softening of the shafts of the bones takes place as in osteomalacia, but this is a comparatively slow process and there may not be time, before treatment is begun, for it to progress to an extent that can be detected clinically.

Rickets occurs at three phases of life, in utero, in infancy, and in adolescence, and also as a complication of diseases such as cœliac disease in which the absorption or metabolism of fats and vitamins is at fault.

Fœtal Rickets occurs when the mother is grossly deficient in vitamin D, i.e. when she has osteomalacia, and therefore it is seen only in countries where osteomalacia is prevalent. The fœtal bones show the ordinary changes of infantile rickets.

Infantile Rickets is the form commonly seen in western countries and is further considered below. It occurs during the period of rapid growth after breast-feeding has ceased when the new diet is defective. Western children during much of the year are protected from the sun by

Carcinoma of the prostate may give rise to secondary deposits befo a prostatic tumour can be detected clinically; indeed malignant chang in the gland are often discovered only after it has been removed a examined histologically. Skeletal metastases are frequently osteoplasi and cause an increase in both the density and the size of the bone. Wh there is very extensive dissemination sufficient bone marrow may destroyed to produce a severe secondary anæmia. The differential diagno from Paget's disease, which may be difficult on radiological grounds alor is facilitated on those occasions when there is an excess of "acid" phc phatase in the blood serum.

X-rays. In osteolytic tumours the outstanding feature is destructi of bone (Fig. 359). The initial deposit is often central and it gradual spreads eroding and destroying the cortex; there is seldom much perioste reaction. There may be but a single bony lesion, or there may be deposi in several bones (the entire skeleton should always be examined), ar sometimes there are multiple foci riddling the bones as if with myelomatos In osteoplastic tumours bone formation proceeds more rapidly than bo destruction and there are areas of increased density of amorphous structur (Fig. 360). Osteolytic and osteoplastic areas may occur in different par of the same bone at the same time.

Treatment

The response to irradiation is, in general, similar to that of the prima tumour. As a rule any particular metastasis can be caused to regress an the bone re-ossifies, but sooner or later other metastases appear in bo and elsewhere, and they cannot be controlled indefinitely—life is prolonge but not saved. Pain of a major character due to nerve involvement ca often be alleviated by irradiation, but occasionally it is necessary to reso to division of the spino-thalamic tract and other operative procedures.

A pathological fracture in the lower limb can make the remainder of tl patient's life so miserable that any alternative is a boon. There need l no hesitation before advising internal fixation of the fracture with Küntscher nail, a nail-plate or whatever may be appropriate either befo or after irradiation.

Prostate. Metastases behave similarly to the primary tumour whe treated with stilboestrol. They usually regress and may be kept in contro often for years, if the daily maintainance dose is continued indefinitel Radiotherapy may be of help with specially large or resistant deposits.

Milkman's Syndrome. This is not a disease entity but a dystrophy at may be encountered when there is hypocalcification from any cause. was first described by Looser in the hunger osteopathies following the st world war and it also occurs in vitamin deficiency osteomalacia, eliac disease, idiopathic steatorrhœa and renal osteodystrophy. *It is* aracterized by the appearance of narrow, radiolucent bands of decreased nsity (often called Looser's zones) running transversely or obliquely ross one or more bones (*Fig.* 301). *The common sites are the pelvis,* mur, ulna, scapula, ribs and metatarsals; the distribution is often mmetrical. There may be localized pain and tenderness, and weakness *often a prominent feature. The treatment is that of the causal condition.*



FIG 301 Looser's lines.

INFANTILE RICKETS

Rickets in western countries is a disease of infancy occurring between he ages of six months and three years. It first became endemic in England uring the earlier part of the seventeenth century and continued rampant ntil recent times. Now, thanks to an improved dietary and more nlightened views as to hygiene, the incidence has greatly decreased; orid rickets is quite a rarity and even minor degrees that are severe nough to affect the development of bone are becoming quite un-ommon.

clothes and therefore they are unable to make good for themselves a dietary deficiency in vitamin D.

Adolescent (or Late) Rickets also occurs during a period of rapid growth when there is a great demand for vitamin D and calcium. It is produced by the same conditions as osteomalacia and is seen in western countries only on rare occasions when some disorder of metabolism is present.

Resistant Rickets. Most infants recover quickly when given moderate doses of vitamin D but there are a few on whom it has no effect. They often respond to enormous quantities of the vitamin, hence the name "vitamin resistant", but it is now thought that they are really a type of renal osteodystrophy caused by defective tubule re-absorption of phosphates (p. 185).

Cœliac Rickets. Cœliac disease is an affection of infancy characterized by diarrhœa with bulky, offensive, fatty fæces, severe wasting, and stunting of growth. Rickets occurs as a complication because the inability to absorb fat from the intestines starves the child of fat-soluble vitamins, and of calcium and phosphorus. During the severest stage of the disease, the bones stop growing entirely and therefore, because no osteoid tissue is formed, the characteristic changes of rickets in the epiphysial discs cannot develop. When growth recommences the typical changes of ordinary infantile rickets are likely to develop unless they are prevented by ensuring a sufficient supply of vitamin D by irradiation with ultra violet rays.

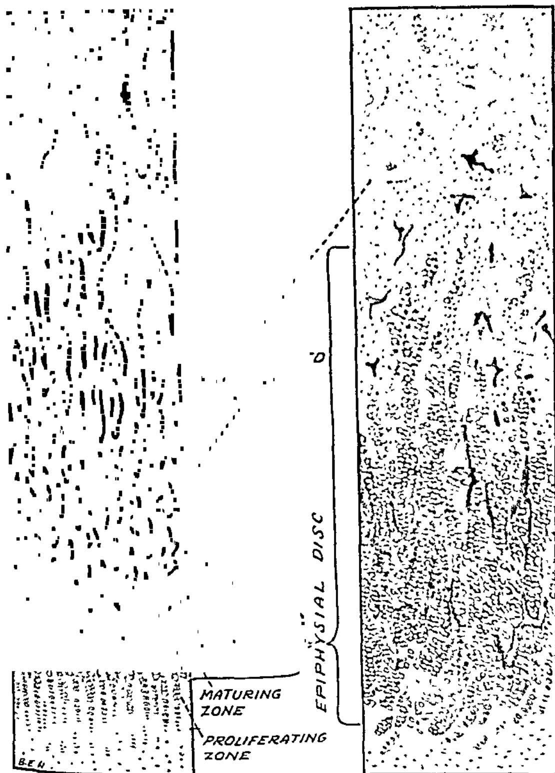
Osteomalacia

Osteomalacia is the counterpart of rickets occurring in the adult. Similar changes do take place during childhood but they are usually less obvious than the concomitant disturbances in growth. The usual form is due to a deficiency in vitamin D and it is prevalent, amongst other countries, in northern India and in parts of China and Japan.

There are two sources of supply of vitamin D; it is produced in the skin by the direct action of the sun, and it is contained in certain foods, notably animal fats. In China the staple diet is grossly deficient in vitamin D; the hours of sunshine, however, are long and since the children play out of doors almost naked, they have sufficient vitamin D, and therefore infantile rickets is uncommon. Older girls and married women, however, live mainly indoors, and because neither source of vitamin D is available, they are liable to develop adolescent rickets or osteomalacia, particularly during pregnancy and lactation when the demand for calcium is greatest. Men working in the fields continue to be protected by the sun and do not suffer from avitaminosis D.

Renal Osteomalacia. Osteomalacia due to vitamin deficiency is seldom, if ever, encountered in Great Britain, but occasionally similar skeletal defects occur as a result of a disorder, usually in the kidneys, which affects the availability of calcium or phosphates (p. 185). In long-standing cases there may be compensatory parathyroid hypertrophy and the resulting fibrocystic changes are superimposed on those of osteomalacia.

PLATE XII



Normal

Rickets

THE EPIPHYSIAL DISC

Magnification ×30 (approx.) Stained H. and E.

N.B.—Osteoid tissue is not shown by this method of preparation.

[To face page 484

Pathology

Deficiency of vitamin D has a twofold effect on the skeleton. The first is that the bones soften because the osteoid tissue which is formed during the ordinary process of remodelling is deficient in calcium. The second and most striking change is at the epiphysial discs (Plate VII). In the normal epiphysis the proliferating cartilage cells become arranged in orderly columns parallel to the axis of the bone, and these cells mature and increase in size as the diaphysis is approached. The columns of cells divide the cartilaginous matrix into trabeculæ, and calcium is deposited in the diaphysial ends of the trabeculæ forming a zone about 4 to 6 cells deep called the zone of provisional calcification. As the cartilage cells mature they are destroyed and replaced by vascular loops growing from the diaphysis; and the trabeculæ, which are now separated by the vascular loops, are covered by a deposit first of osteoid tissue and then of bone.

In rickets the epiphysial disc is very much thicker than normal; all zones are widened including the zone of provisional calcification, but this last may be quite indistinct or absent. There is complete absence of the normal regular arrangement and the disc consists of a disorderly mass of cartilage cells, trabeculæ, osteoid tissue and poorly calcified bone. The vessels enter the cartilage in all directions, and islets of cartilage may persist far along the diaphysis.

The breadth of the epiphysial disc is increased by the deposition of osteoid tissue under the perichondrium, thus causing enlargement of the end of the bone.

The changes are most marked in the larger long bones. The epiphyses are enlarged, growth is checked, and after a time the bones soften and bend in such a direction as to increase the normal curvature. Fractures, particularly greenstick fractures, occur readily and the callus is exuberant and soft.

Clinical Features

The full picture unfolds gradually as the condition progresses from the earliest sub-clinical stage to florid rickets.

The typical case occurs during the second half of the first year of life. The first symptoms to be noticed are not infrequently restlessness and irritability; the infant may appear healthy and is often fat, but the muscles are flabby. The fontanelles are wider than normal and areas of softening may be palpable in the cranial bones, specially in the posterior parts of the parietal bones. The X-rays at an early stage are normal.

The appearance when the disease is well-developed is characteristic. The child looks flabby and unhealthy and has a protuberant abdomen, but wasted limbs; the head is square, the thorax distorted and a "rickety rosary" is palpable. The epiphyses of the long bones are enlarged and the legs may be deformed.

Deformities. The gross deformities so common in the last century, and even in the first two decades of this century, are now seldom seen in Great Britain.

The ribs are usually affected severely in florid ickets. Enlargement of the costo-chrondral unctions produces the typical "rickety rosary," nd softening of the shafts of the ribs allows them o bend at points of stress, e.g. at the attachment of he diaphragm to form a Harrison's sulcus.

Deformities of the legs are due partly to rregularity in growth of the epiphyses and partly o softening. The femora bend outwards causing nock knee (p. 31), and the tibiae curve inwards nd often backwards causing bow legs (p. 35). Sometimes both deformities are combined and then he legs look fairly straight on casual examination.

The pelvis is not infrequently compressed into characteristic tri-radiate shape. The femoral ecks bend causing coxa vara (p. 170). The skull becomes soft (craniotabes), and the fontanelles are abnormally wide. Deformities of the spinal column occur when the disease continues unchecked for a ong time.

Fig. 362. Florid rickets.

X-rays (Fig. 362). The first changes are often n the wrist (lower end of ulna) and knee. The extremity of the metaphysis first loses in density hen it becomes concave or "cupped" and its outline blurred. Later the metaphysis is broadened, ometimes becoming bulbous, the cupping increases and the concavity of the cup appears "frayed" or "feathery." After treatment, the structure gradually returns to normal.

RENAL OSTEODYSTROPHY

(*Synonym*) Renal Rickets

Defective calcification of bone may occur when there is a renal defect which interferes with the balance of calcium, phosphates and other normal constituents of the blood. Of recent years two main groups have been separated :—

(1) Renal failure due to imperfect glomerular filtration. This is the common form and includes chronic uræmia caused by congenital abnormalities of the kidneys, congenital dilatation of the ureters, and so forth. Secondary parathyroid hyperplasia is not uncommon and the resulting fibrocystic changes in bone may mask those due to defective ossification. The prognosis and treatment are those of the general condition.

(2) Renal disorders involving defects in the function of the tubules. Several types can be distinguished according to the function or combination of functions that is disturbed, but the chemical and the

AVITAMINOSIS C

(*Synonym*) Scurvy

Scurvy, a disease due to deficiency of the water soluble vitamin C, is now a rarity in most countries although an occasional case still occurs as the result of excessive zeal in the sterilization of infants food—vitamin C is rapidly destroyed at a temperature of 100°C.

The disease, which is characterized by capillary hæmorrhage, occurs in any part of the body and appears to be associated with a disorder in normal fibroblastic differentiation. The conspicuous feature in infants is subperiosteal hæmorrhage at the ends of the long bones, usually of the lower limbs. The legs become slightly swollen and exceedingly painful to touch; they are held quite immobile, as if paralysed, and any attempt to move them is vociferously resented. There may also be bleeding from the kidneys and intestines, and from the gums if the teeth have erupted.

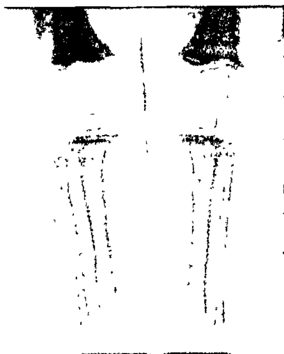


Fig 364. Scurvy

The X-rays (Fig. 364) in infants show general osteoporosis with thinning of the cortical bone and possibly some subperiosteal new bone. At the extremity of the diaphysis there is a line of dense bone with a radio-translucent line ("the white line") next to it. The ossifying centres of the epiphyses are sharply outlined.

Scurvy also occurs in adults, usually sailors and arctic explorers, when they are deprived of fresh foods for long periods. Hæmorrhage occurs first from the gums and later under the skin and mucous membrane. In severe cases there may be localized subperiosteal hæmorrhages; when a subcutaneous bone is affected the overlying skin breaks down to form a foul ulcer, and occasionally the bone becomes necrotic.

clinical findings have not yet been fully correlated. It seems that in all there is defective tubule re-absorption of phosphates, whilst in some re-absorption of glucose, potassium and various of the amino-acids is also imperfect. In some types, the kidneys are unable to clear an acid urine.

It is highly probable that those types in which the principal defect is in the clearance of phosphates include the condition formerly known as vitamin D resistant rickets (p. 482). It can often (but not invariably) be cured with enormous doses of vitamin D, apparently because this modifies tubule re-absorption of phosphates.

The types with errors in re-absorption of glucose and amino-acids include *Fanconi's syndrome* and other similar disorders. This condition starts in childhood when the general picture resembles that of rickets,



Fig 363 Renal osteodystrophy

but it may not be discovered until later in life when the skeletal changes are those of osteomalacia. Treatment is difficult and, although some patients respond satisfactorily, this is not the rule.

The types in which acidosis is the prominent feature have previously been known by a variety of names. They are perhaps the most satisfactory to treat because of the excellent response to alkalis which can, if necessary, be continued indefinitely.

The radiological changes in the bones consist in (*a*) general decalcification and (*b*) changes in the epiphysial discs resembling those in florid rickets (Fig. 363). Closure of the epiphyses is delayed, but growth is slow and many patients are so stunted as to warrant description as "renal dwarfs." Progressive knock knee is a common feature and it may be the first symptom to appear.



FIG 365 Hyperparathyroid osteoporosis in a girl aged 18 A parathyroid tumour was removed by Sir G Gordon-Taylor in 1929, the bones recalcified and the patient has since had two children

HYPERTHYROID OSTEOPOROSIS

Some generalized decalcification of the skeleton commonly occurs in long-standing cases of hyperthyroidism, but as a rule it is trivial in extent and can only be detected in carefully controlled radiographs. Occasionally, however, decalcification is extreme and the cortical bone is reduced in thickness to a mere shell.

The exact reason for the loss of skeletal calcium is not certain. The calcium and inorganic phosphorus content of the serum are within normal limits, but their excretion in both urine and fæces is increased. Control of the metabolic rate by partial thyroidectomy reduces the rate of excretion of calcium and inorganic phosphorus, but it is not as a rule followed by recalcification of bone (Snapper).

The most constant symptom in severe cases is tenderness on deep pressure over the bones. The long bones are readily fractured and the bodies of the vertebræ may collapse. X-rays show decalcification of all bones; the cortex is narrowed but the Haversian canals are not enlarged and the trabeculæ retain their normal arrangement.

Hyperthyroidism in children is accompanied by an increase in thickness of cortical bone and by delay in both the appearance of the epiphyses and the time of the closure of the epiphysial discs.

HYPER-PARATHYROIDISM

Enlargement of the parathyroids occurs in at least two different sets of circumstances :—

(1) *Primary.* A primary adenoma affecting a single parathyroid gland and causing generalized fibrocystic disease.

(2) *Secondary.* Parathyroid hyperplasia affecting all the parathyroid tissues ; it occurs secondarily to chronic renal failure, osteomalacia and occasionally other generalized affections of the bone. It may cause some decalcification with fibrocystic changes, but not to the extreme extent occurring in fibrous dysplasia or generalized fibrocystic disease.

Generalized Fibrocystic Disease

(*Synonym*) von Recklinghausen's Disease

This condition is the result of the excessive secretion of parathyroid hormone due to the presence of a parathyroid adenoma. The total excretion of calcium from the body becomes greater than the total intake, the excess being obtained from the bones (negative calcium balance). The serum content of calcium and of phosphatase is raised, and there is an increase in the calcium and a decrease in the inorganic phosphorus excretion in the urine. The bones undergo osteoclastic resorption of the trabeculæ, and this is accompanied, as is usual when bone is broken down rapidly for any reason, by proliferation of fibrous tissue in the bone marrow.

Symptoms. The condition may occur at any age and in any country. The onset is marked by gradually increasing fatigue and aching in the bones. The skeleton softens, the bones become deformed and spontaneous fractures are common ; there is usually marked tenderness to deep pressure over those bones in which changes are most active. The diagnosis is based on the X-ray appearances and the biochemical findings of a raised serum calcium and a negative calcium balance.

X-rays (Fig. 365). There is a general decrease in density of the whole skeleton that is slight at first but ultimately becomes extreme. Some bones are affected more severely than others, but the very wide distribution stands in marked contrast to other conditions such as Paget's disease in which some bones always remain normal.

The cortex of the bones becomes thinner and the margins have a scalloped appearance at areas where active resorption is in progress. Trabeculæ in the cancellous bone disappear or are replaced by coarse strands arranged in the axis of the bone. There are often localized areas of cystic enlargement somewhat resembling osteoclastomata and usually occurring at places where the bone has been injured.

Treatment. Removal of the parathyroid adenoma cures the condition and the bones gradually regain a normal structure. Parathyroid tissue is not confined to the thyroid gland but may occur at a number of situations in the neck and superior mediastinum. An extensive search, which may involve splitting the sternum, is sometimes necessary before the tumour is located.

PAGET'S DISEASE

(*Synonym*) Osteitis Deformans

This is a condition of unknown ætiology in which the structure of a number of bones, but never of the entire skeleton, is gradually modified. It occurs most frequently in people over forty years of age, but occasionally someone much younger is affected. Sir James Paget, who first described the disease in 1876, considered it to be inflammatory. This view is no longer tenable, and although the real cause is still uncertain, present day opinion inclines to the view that it can be explained on a basis of local hyperæmia, perhaps of metabolic or endocrine origin.

The histological picture is of bone absorption accompanied by somewhat haphazard new bone formation and fibrosis of the bone marrow. Bone formation is more rapid than destruction, hence the bulk of the bone is increased; but calcification of the new bone is incomplete, so it remains soft. During periods of remission absorption of bone ceases but calcification continues (*osteo-sclerotic type*), and in exceptional cases the bone becomes ivory hard.

Clinical Features

Symptoms are present, at any rate during the earlier stages, in not more than half the patients; in the remainder radiological changes are found in the course of examination for some other reason. The first complaint may be of deformity, or sometimes there is a "spontaneous" fracture, but usually it is of pain or aching in the affected bones. In the later stages pain is often a serious feature, and although occasionally the disease is nearly painless throughout its course, most patients suffer from a constant ache deep in the bones; in a few the pain is so severe as to make life nearly intolerable.

Not infrequently only a single bone is involved, but more often several are affected at the same time. The order of frequency is spine, sacrum, pelvis, skull, femur, clavicle and tibia (Schmorl). The bones become progressively thicker and they are gradually deformed under the influence of the body weight. When the tibia is affected the increase in size and the exaggeration of its normal curve are conspicuous. Involvement of the skull causes the size of the head to increase gradually making it necessary, so it is said, to get a larger size in hats each year. Deafness due to affection of the petrous bone is common, and this may be the complaint leading to the diagnosis.

Fractures are usually transverse and occur principally in the long bones at sites of stress; union is not greatly delayed. Incomplete linear fractures ("pseudo" fractures) on the convex side of curved bones are common (Fig. 369), and compression fractures of the spine are seen occasionally.

The length of life is not usually reduced and many patients live to a ripe old age troubled only by increasing deformity and perhaps pain. In about five or ten per cent, however, one of the affected bones undergoes malignant changes and this is invariably fatal.

HYPERPITUITARISM

The secretion of the cells of the anterior lobe of the pituitary gland influences the growth of the skeleton. Excessive secretion is usually due to a chromophil adenoma of the anterior lobe; in children this causes gigantism, and in adults acromegaly. A basophil adenoma gives rise to Cushing's syndrome in which one feature is a severe, progressive osteoporosis resulting from lack of protein to form the matrix of bone.

Gigantism

Excessive secretion of the anterior pituitary hormone during the growth period results in a general increase in the growth of all bones. There is an increase in thickness as well as in length and the skeleton remains of more or less normal proportions. Growth at the epiphysial discs is more rapid than usual, and since they also remain open longer, a huge size may be reached (Fig. 366). The bones of the skull are affected, but the facial bones, particularly the mandible, often show proportionately excessive growth. The teeth remain of normal size.

Acromegaly

Excessive hormonal secretion after the epiphyses have closed causes increased growth only in the thickness of the bones. The more obvious features in a classical case are enlargement of the mandible, the supra-orbital ridges, the nose, and the hands and feet (Fig. 367). It is, however, usual for the entire skeleton to be affected to some extent and the vertebræ, the ribs and the tubular bones all become thicker and more massive.

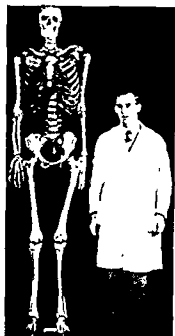


Fig. 366 Skeleton of a man 7ft. 7in tall standing beside a man of 5ft 10½in (from the museum of the R C S Eng)



Fig 367 The skull of an acromegalic (from the museum of the R.C.S. Eng).



FIG 369 Paget's disease of the tibia Note the "pseudo" fractures

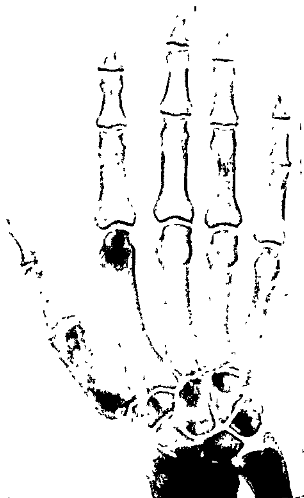


FIG. 370 Paget's disease, osteosclerotic type.

LEONTIASIS OSSEA

This is not a disease entity but a term descriptive of a single symptom —enlargement of one or more of the facial bones—that may be due to a variety of causes. In an extreme instance the whole face is distorted until it is possible to imagine some slight resemblance to a lion.

Typically the condition starts in childhood when the bony enlargement is caused either by a diffuse osteoperiostitis due to gross dental sepsis, or else by some disease of bone, usually fibrous dysplasia. In adults a similar appearance can be caused by Paget's disease, syphilitic osteoperiostis and tumours of the nose and air sinuses.

The course and prognosis are those of the underlying condition. Treatment is seldom possible.

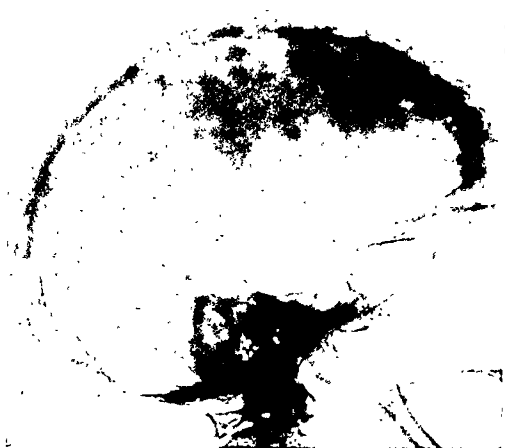


Fig 368. Paget's disease of the skull.

X-rays (Figs. 368, 369 and 370). The intimate structure of the bone is entirely altered. The cortex is thickened by subperiosteal deposition of new bone and by encroachment on the marrow cavity. The density of the bone is diminished, and the normal trabecular pattern disappears, being replaced by thick, irregular trabeculæ. When the vault of the skull is involved, it becomes thickened and has a "cotton wool" appearance. In the osteosclerotic type the bone is greatly increased in density and has a homogenous structure.

The diagnosis depends on the X-ray appearances and sometimes, especially when the only bones to be involved are one or two vertebræ which have collapsed, it cannot be made immediately. The alkaline phosphatase is often raised, particularly when bone formation is active.

Treatment

No treatment at present known has any effect on the course of the disease. The chief clinical problem is the control of pain, and since this arises within bone, little can be done except to administer suitable analgesics. Radiotherapy, in the writer's experience, is without effect. When the bones soften so much that the deformity becomes progressively worse, apparatus such as a weight-relieving caliper or a spinal support may be required. Fractures unite satisfactorily but rather more slowly than usual.



FIG 369. Paget's disease of the tibia Note the "pseudo" fractures



FIG. 370 Paget's disease, osteosclerotic type

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INFANTILE CORTICAL HYPEROSTOSIS

This affection, of which the outstanding feature is the deposition of subperiosteal bone in the mandible, clavicle and shafts of the long bones, is proving to be less uncommon than was thought when it was first described. The cause is unknown; there is no evidence of inflamation or of a metabolic or endocrine disorder, and there is no demonstrable association with trauma. On several occasions more than one child of the same parents have been affected.

The onset is usually before six months of age although in a small group it is between twenty and thirty months. The mandible is involved in rather more than half the patients, and any of the long bones, the clavicle and the scapula may be affected, usually several at a time. The first sign

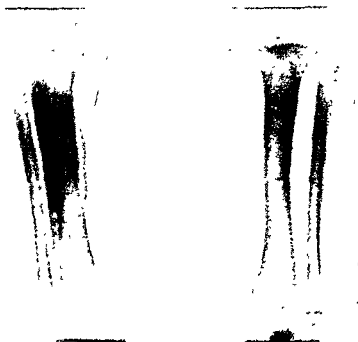


FIG. 371 Infantile cortical hyperostosis affecting the right tibia of a child aged twenty months

is pain accompanied or quickly followed by swelling. Tenderness is severe and all handling and movement of the affected part is resented. Soft tissue swelling and bony thickening can usually be detected. The temperature is often slightly raised but there are no signs of inflamation.

The first radiological change is the appearance of a periosteal shadow along part or the whole length of the bone. The shell of new bone increases in thickness and in time blends with the cortical bone (Fig. 371). Resolution takes place spontaneously but it is several months before the bone regains a normal appearance.

The course of the disease is short. Resolution begins within a few weeks and the symptoms subside quickly. Sometimes there are several attacks affecting different bones with an interval of weeks between each. No useful treatment is known.

CONGENITAL DEFECTS OF THE SKELETON

OSTEOGENESIS IMPERFECTA

(*Synonyms*) Osteopsathyrosis, Fragilitas Ossium

This is a disease, sometimes *familial*, in which the bones have an increased fragility and fracture with ease, often as the result of only slight trauma. The bones may also be soft and bend causing striking deformities. In many patients, but not all, the sclerotics of the eyes are blue, and amongst those reaching middle-age otosclerosis is common.

Growth of the bones in length is not as a rule grossly impaired but there may be marked dwarfing caused by bending of the limbs and spine. Growth in thickness is greatly diminished, chiefly because the cortical layer is deficient; there is but a thin cortical shell which often fails to extend the full length of the shaft and leaves an area of cancellous bone near the metaphyses without support (Fig. 372). The deeper layers of the cortex are replaced by *cancellous bone in which may be* included areas of incompletely calcified osteoid tissue.

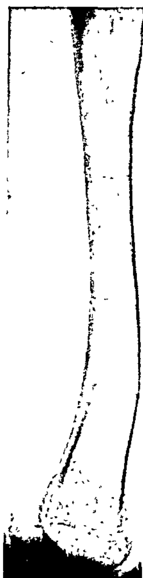


FIG 372 Osteogenesis imperfecta.

There are two clinical types which merge with one another. In one type the disorder develops in utero and there are multiple fractures before, during and *immediately after birth; in the other type* fractures do not commence until later in infancy or childhood, and they occur less frequently. The later in life the disease becomes manifest, the better is the prognosis. Many children fail to survive when the trouble is present at birth, but should they live the bones gradually become stronger and by the time growth has ceased the structure approximates to normal. No specific treatment is known but fractures unite satisfactorily. Occasionally hyperplastic callus is formed which bears a close radiological and histological resemblance to sarcoma, but it is benign.

Fairbank *recognizes three radiological types:*

Thick bone type occurring only in severe pre-natal cases. The major long bones are short, thick and broad, although the cortex is thin, and the general appearance somewhat resembles achondroplasia. It is seldom met *after three months of age.*

Slender, fragile bone type which includes pre-natal cases surviving more than a few months, and all post-natal cases. The skeleton as a whole is osteoporotic, and the long bones may be extremely slender.

Osteogenesis imperfecta cystica, a very rare type in which the long bones, in addition to a deficiency in the cortex, show a pronounced honeycombed, or cystic, appearance.

ACHONDROPLASIA

(*Synonym*) Chondrodystrophia Fœtalis

This is an hereditary condition, probably transmitted as a simple dominant Mendelian characteristic, in which the limbs are short but the trunk is of normal size. The primary cartilage of the affected bones ossifies early, the epiphysial cartilage fails to proliferate normally, and the combined effect is to diminish growth in length. The base of the skull is also affected and fails to grow properly, and since the cranium develops to a normal size, the head has a hydrocephalic appearance.



Fig. 373 X-ray of a still-born child with achondroplasia.

Achondroplasic dwarfs, the usual dwarfs of the circus, are recognizable clinically by *the shortness of the limbs in contrast to the trunk—the hands* when hanging by the sides may hardly reach the hips; by the saddle-shaped nose and prominent forehead due to shortening of the base of the

skull; by the marked lordosis attributable to alteration in the shape of the pelvis and the position of the acetabulæ; and by the short, stumpy fingers with deviating ring and middle fingers. Mental development is not greatly impaired.

Radiologically the shafts of the long bones are normal in diameter but they are very much shortened, and the bosses where muscles are attached are exaggerated giving an impression of great strength. The epiphyses appear wider than usual and the cortex of the shaft thicker, but neither is actually enlarged and the appearance is due to the altered proportions of the bones. The fibula and ulna are often relatively shorter than the tibia and radius and this causes bowing of the limbs.

DIAPHYSIAL ACLASIS

(*Synonyms*) Hereditary Multiple Exostoses, Hereditary Deforming Chondrodysplasia

This is a congenital and often familial disorder of growth in which the growing ends of the long bones fail to model properly. During the normal course of growth newly-formed bone is modelled into cancellous and cortical portions and adjusted to the required external shape; this entails a reduction in breadth from that of the epiphysial discs to that of the shaft (Fig. 374). In diaphysial aclasis the modelling process is at fault and the metaphysial end of bone remains broad and thick, and also gives rise to a number of exostoses. Bones formed entirely within cartilage (i.e. the epiphyses, the carpal and tarsal bones, and the vertebral bodies) and bones formed within membrane are never affected.

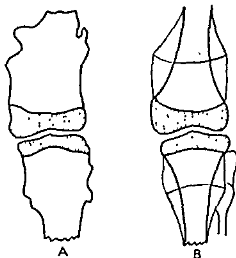


FIG 374. The normal process of modelling during growth (B) does not take place in diaphysial aclasis (A) (after Keith)

The condition affects males more often than females. It manifests itself gradually during childhood or adolescence when the presence of the bony protuberances, and often of deformity, is first noticed. Any of the tubular bones may be involved but most often those around the knee, ankle and shoulder. Sometimes only one or two sites are affected, but



FIG 375 Diaphysial aclasis showing broad metaphyses and multiple exostoses



FIG 376 Diaphysial aclasis with bowing of the radius and shortening of the ulna

frequently both ends of nearly every long bone in the skeleton are distorted and there are literally scores of small exostoses. Bowing of the forearm is a typical deformity; it is caused by the radius growing more rapidly than the ulna, and both the radio-humeral joint and the lower radio-ulnar joint may be dislocated (Fig. 376).

Treatment is indicated only for the correction of deformity and for the removal of any exostoses which happen to be causing symptoms.

OSTEOPETROSIS

(*Synonyms*) Albers-Schönberg's Disease, Marble Bones

This is a rare condition, sometimes familial, which is probably present at or soon after birth although it may not be diagnosed until later childhood or adult life. The bones are densely calcified but somewhat fragile, and the primary disorder appears to be due to lack of resorption and proper modelling of the internal structure whilst they are still immature.

Radiologically the affected parts of the bones have a dense, homogenous structure. A dense band appears in the metaphysis and seems to travel along the shaft during growth; either the whole of the bone becomes dense, or else dense rings are formed, according to whether the process is continuous or intermittent (Fig. 377). Ring formation in the ilium is a



Fig. 377 Osteopetrosis (by courtesy of Mr. W D. Coltart)

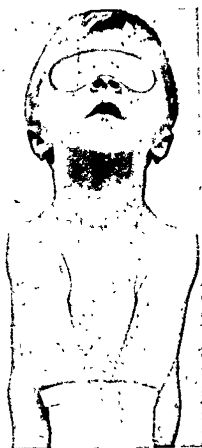


Fig 378 Cleido-cranial dysostosis (by courtesy of Sir H A T. Fairbank).

typical feature. The metaphyses may become broad and club-shaped, and the epiphyses are sometimes of irregular density or stippled. The appearance of the vertebræ can be very striking.

In adults the first indication is occasionally severe anæmia caused by the loss of hæmatopoietic marrow Sometimes the internal auditory meatus and optic foramen are reduced in size and there is interference with hearing and sight. When symptoms become manifest during early childhood the prognosis as regards life is poor.

CLEIDOCRANIAL DYSOSTOSIS

This is a rare and often hereditary condition in which the outstanding defects are failure in development of all or part of the clavicles, and delay in closure of the cranial sutures and fontanelles. As a rule the cranial vault is large, the base of the skull and face are small, the milk teeth are stunted and eruption of the second teeth is delayed. In addition individual cases have been reported in which the pelvis, the femoral neck, and the metacarpals, metatarsals and phalanges are also of faulty development.

Patients usually suffer remarkably little inconvenience from the absence of clavicles and come to regard the ability to bring their shoulders together in front of the body as a parlour trick.

Fig 379. Dyschondroplasia. *Left* in a boy aged 10. *Right*. in a woman aged 22.



Fig 380 Dysplasia epiphysialis multiplex. All the large joints were affected

DYSPLASIAS OF METAPHYSES AND EPIPHYSES

A variety of conditions in which there is faulty development of the metaphyses, the epiphyses, or both have been described by many authors who have given them almost as great a variety of names. Not infrequently the same condition has been given a succession of names each of which is considered by its originator to be an improvement on the previous ones. Sometimes but a single instance has been recorded, sometimes several cases resemble each other sufficiently to form a definite group, and yet others are common enough to be accepted provisionally as clinical entities. In the course of time, when more individual cases have been published, the grouping of these abnormalities may become clearer. Already achondroplasia, diaphysial aclasis and osteopetrosis, which at one time were included under the general heading of dyschondroplasia, have been separated as genetically distinct abnormalities. It may be that eventually the remaining disorders will either reveal themselves as special instances of a more general defect, or they will be recognized as true entities. A few examples are briefly mentioned below.

Dyschondroplasia

(*Synonym*) Ollier's Disease

This is the least uncommon of the group. The metaphyses are affected principally, but ossification of the epiphyses may also be irregular. The defect appears to be in the ossification of the growth cartilage, portions of which remain but partly calcified until growth has ceased.

Any of the long bones may be affected, and in about one-third of all cases the distribution is unilateral. The typical radiological appearance is of translucent stripes about one-third of an inch wide running obliquely across the diaphysis (Fig. 379); similar stripes are often seen in the alæ of the iliac bones. There may be a number of translucent zones in the phalanges resembling enchondromata, and many of the cases described as "multiple enchondromatosis" should probably be classified as dyschondroplasia. After the epiphyses have closed irregular calcification takes place and gives the ends of the bones, which are expanded and mis-shapen, a speckled appearance. Genu valgum due to bending of the lower ends of the femora has been observed on a number of occasions and osteotomy was followed by union in the usual time.

Maffucci's syndrome is a condition in which dyschondroplasia is associated with cavernous hæmangiomata and phleboliths.

Dysplasia Epiphysialis Multiplex

This condition, sometimes described as multiple osteochondritis, is one in which the epiphyses appear late, close late and ossify irregularly, sometimes from multiple centres. The epiphyses are irregular in density and shape, and usually they are flatter and less convex than normal (Fig. 380). The limbs are often short and the fingers and thumbs strikingly stumpy. The X-ray appearance of the ankles and shoulders is usually the deciding factor in the diagnosis.

Morquio's Disease

The vertebral bodies are irregular in size and shape, biconvex, narrower from above down, and with a "tongue-like" projection from the anterior surface (Fig. 381). All the long bones including those of the hands and feet may be affected, and the epiphyses may be irregular in shape and stippled. There are many individual variations.





Left Fig 381 Morquio's disease.

Above Fig 382 Osteopoikilosis

Osteopoikilosis

This condition is sometimes but not always hereditary and probably has no kinship with those already described. The bones are normal in all respects except that they are spattered with ovoid or round islands of dense bone (Fig. 382). It may be found at any age and causes no direct symptoms, although instances associated with other conditions which do cause symptoms, such as familial dermatofibrosis, have been recorded.

CHAPTER XV

DISEASES OF THE NERVOUS SYSTEM

POLIOMYELITIS

(*Synonym*) Infantile Paralysis

Poliomyelitis is an acute disease in which there is widespread infection of the central nervous system. It is caused by a neurotropic virus of which there are three distinct strains all having a special affinity for the grey matter of the spinal cord. The basal ganglia and cortex are not as a rule affected severely, but occasionally they bear the brunt of the infection. The virus can be recovered from the central nervous system only after there is clinical evidence of infection, such as a rise in temperature. It is, however, present in the circulating blood some days earlier and this is now thought to be the route by which it reaches the central nervous system.

The changes in the spinal cord are of two kinds; firstly there is an inflammatory reaction around the capillary vessels of the grey matter and diffuse infiltration of the grey matter with polymorphonuclear leukocytes, and secondly there may be degenerative changes in the anterior horn cells. The affected cells may either be put out of action temporarily by pressure of the surrounding œdematous tissues, or they may be destroyed permanently by toxins produced by the action of the virus or as the result of deprivation of their blood supply.

Epidemiology

The disease occurs in sporadic and epidemic forms. In Great Britain sporadic cases are reported every year in some numbers, mostly between the months of July and October; major epidemics have not yet occurred although from time to time sufficient cases are congregated in one locality to be regarded as a minor epidemic. The 1947 outbreak was of considerable size. In the United States of America the incidence is higher and severe epidemics are frequent. There is no doubt that the incidence is increasing throughout the world both in countries where it existed before and in those which, until recently, have been relatively immune. The arrival of the virus in a new country is often heralded, as has happened in Malta, Mauritius, Peru and Jamaica, by a sizeable epidemic.

There is uncertainty as to the principle method of dissemination, but since it became possible to grow the virus in a tissue culture and then to

recognize its presence without animal innoculation, several extensive investigations have been carried out. It has been found that during an epidemic the virus can be recovered from the fæces of a large majority of the population, both children and adults, even though they have no clinical signs of infection. It is improbable that the virus is passed from person to person by direct contact because it is seldom that several members of one family, or those with medical care of patients, show clinical signs of the disease. Observations such as these have led some authorities to believe that during an epidemic infection is almost universal and therefore control must be impossible. On the other hand it has been found that there is a greater incidence of clinical infection amongst families containing a child of school age (although it is not necessarily the child that is affected) and this suggests that control should be possible. Attention is given to such problems as the contamination of food by careless handling or by flies, and contamination of water, both the main supply and swimming pools.

Prognosis

The prognosis varies with different epidemics, and apparently with different strains of the virus. The mortality is greater amongst adults than children. The usual cause of death is respiratory paralysis, but it can be due to intercurrent disease, particularly in infants who may die of enteritis and marasmus.

There is complete recovery without any paralysis at any stage in a large percentage of those surviving the acute phase, the proportion varying from 25 per cent to 75 per cent in different epidemics. Recovery from paralysis depends on whether the anterior horn cells have been damaged temporarily or permanently ; the extent of the initial paralysis, therefore, is not a reliable guide to prognosis, and some patients with severe initial paralysis return almost to normal.

Clinical Features

Persons of either sex may be affected. The greatest incidence is usually from two to five years of age but it varies in different outbreaks and no age is immune.

There are three distinct clinical phases in the course of the disease :—

Phase of *onset.*

,, ,, *recovery.*

,, ,, *residual paralysis.*

Phase of Onset. The reaction to the initial infection varies greatly in different epidemics and in different individuals in the same epidemic. It may be :—

(a) *Sub-clinical.* There are no general or local symptoms. Evidence of infection can only be obtained by recovering the virus from the nasopharynx or stools and identifying it by culture.

(b) *Abortive.* An influenzal-like, pyrexial attack of brief duration, and unaccompanied by paralysis. Clinical diagnosis is presumptive and can only be made during an epidemic.
(c) *General Symptoms without Paralysis.* The general symptoms resemble those described below and there are identical changes in the cerebro-spinal fluid.
(d) *General Symptoms with Paralysis.*
(e) *Paralysis without General Symptoms.* The patient wakes in the morning unable to move certain muscles or limbs.

The incidence of sub-clinical and abortive infection is not known but it must be very high because of the frequency with which the virus can be recovered from the fæces during epidemics and the apparently high immunity of adults in many countries. It is probable that most of the population has been infected at some time or other without being aware of it.

GENERAL SYMPTOMS. In many instances the onset is marked by symptoms resembling those of any acute infection. The child is feverish, often for only a day, with a temperature of 100° to 101°, and there may be general malaise, headache, drowsiness, and perhaps diarrhœa and vomiting. Occasionally there is high fever and delirium. Muscular tenderness is usually a prominent feature and is evident early; pain on joint movement also occurs early, probably because this involves movement of muscles, and infants resent handling, nursing, and changing of napkins. At a later stage headache becomes more severe and there is usually pain and stiffness of the back and neck. Somnolence is sometimes marked, anorexia is common, and an initial diarrhœa frequently gives way to obstinate constipation.

Another mode of onset that is fairly often seen, at any rate in Great Britain, is characterized by more gradual development. There is an initial mild fever lasting two or three days, followed by a period of remission of a few days, and then a rather more severe, but indefinite, illness. Muscle pain and tenderness and stiffness of the neck may be delayed a little longer, and paralysis does not appear until perhaps a fortnight after the first symptoms.

The pressure of the cerebro-spinal fluid is raised and the cell count gradually rises to 50–250 per cubic millimetre. At first the increase in cells is shared by both polymorphs and lymphocytes, but the proportion of lymphocytes increases steadily. There is a gradual but moderate rise in both protein and globulin content of the C.S.F.

PARALYSIS often appears shortly after the general symptoms but it may be delayed for several days, and sometimes, when there has been no general disturbance, paralysis is the first feature to be noticed. Paralysis usually reaches a maximum within a few hours—gradual development is of bad prognosis. It is flaccid in type and may affect a single muscle, a group of muscles, or a complete limb or limbs. Sometimes there is weakness instead of complete paralysis. Paralysed muscles are nearly always tender at first, but by no means all tender muscles become paralysed.

Paralysis characteristically is asymmetrical and patchy; some muscle

Voluntary Power Chart

Number Code
- 0 No contraction
- 1 Flicker or trace of contraction
- 2 Active movement with gravity eliminated

Number Code
- 3 Active movement against gravity.
- 4 Active movement against gravity and resistance.
- 5 Normal power.

RIGHT NECK AND TRUNK					LEFT NECK AND TRUNK			
				Date of Test				
				Retrocollic Muscles				
				Sterno-Mastoid				
				(i) Sternal Head				
				(ii) Clavicular Head				
				Intercostals				
				Abdominal Muscles				
				Diaphragm				
				Erector Spinae				
				Abdominal reflexes				
RIGHT UPPER LIMB					LEFT UPPER LIMB			
				Trapezius				
				Rhomboids				
				Pectoralis Major				
				Serratus Anterior				
				Deltoid				
				Adductors of Shoulder				
				Int. Rot. of Shoulder				
				Ext. Rot. of Shoulder				
				Biceps				
				Triceps				
				Brachio Radialis				
				Ext. Carpi Radialis				
				Ext. Communis Dig.				
				Ext. Carpi Ulnaris				
				Supinator				
				Abductor Poll. Long				
				Ext. Pollicis Longus				
				Ext. Indicis Proprius				
				Pronator Teres				
				Flex Carpi Radialis				
				Palmaris Longus				
				Flex Sub. Digitorum				
				Flex Carpi Ulnaris				
				Flex Profundus Dig.				
				Flex Longus Poll.				
				Abductor Pollicis				
				Opponens Pollicis				
				Adductor Pollicis				
				Interossei				
				Lumbricals				
				Reflexes { Biceps				
				Supinator				
				Triceps				
RIGHT LEG					LEFT LEG			
				Hip Flexors				
				Hip Extensors				
				Hip Abductors				
				Hip Adductors				
				Int. Rotators of Hip				
				Ext. Rotators of Hip				
				Quadriceps				
				Hamstring Group				
				Tibialis Anterior				
				Ext. Longus Hallucis				
				Ext. Digitorum Longus				
				Peronei				
				Gastrocnemius				
				Flex. Longus Hallucis				
				Flex. Digitorum Longus				
				Tibialis Posterior				
				Intrinsic Foot Muscles				
				Reflexes { Knee				
				Ankle				

groups are involved more frequently than others and the distribution varies to some extent with the epidemic. Any spinal segment may be affected but the brunt is usually borne by the lumbar enlargement of the cord (L2—S1), and therefore paralysis is *most common in the lower limbs* (80 to 90 per cent). The abdominal and spinal muscles are seldom affected alone, but usually in conjunction with the legs. The arms are involved in 30 to 50 per cent of patients, sometimes alone but more frequently at the same time as the legs. The facial muscles are little affected in most epidemics, although with bulbar infection there may be facial, pharyngeal, lingual and occular paralysis.

DIAGNOSIS. *Poliomyelitis is seldom diagnosed during* the pre-paralytic stage except during an epidemic, but it should be considered in a child or young adult when there is an acute fever of moderate severity accompanied by stiffness of the neck or back. There may or may not be drowsiness, irritability and muscle tenderness. A steady increase in the lymphocyte count and the protein content of the cerebro-spinal fluid is strong presumptive evidence, but it is not absolutely diagnostic.

Phase of Recovery. *During this phase there is partial or complete* recovery of the paralysed muscles; it is unusual for there to be no recovery at all. Improvement usually commences within a week or two; there is seldom much progress until muscle tenderness has diminished, and then there may be a rapid advance for two or three months followed by slow but steady improvement during the next year. It is very unlikely that a severely paralysed muscle which has failed to show any sign of recovery during the first few *months* will subsequently gain useful power. Although recovery is spontaneous, careful treatment at this stage is essential to ensure the greatest possible gain in power and co-ordination, and to prevent contractures.

Phase of Residual Paralysis. With good treatment the condition is likely to become stationary within two years and no further improvement can be looked for. The problem then is to provide the best possible function with the help of operation and apparatus, and to help the patient to adapt his life to his altered physical condition.

Treatment

Immunization. *Passive immunization* with gamma globulin, which includes the appropriate antibodies, has undergone extensive trials that so far have been inconclusive. If attempted during an epidemic there is a risk of giving the injection during the incubation period and causing paralysis at the site of injection. The method is not receiving as much attention as heretofor.

Active immunization using a killed virus vaccine is now being attempted but at the time of [illegible] he experimental stage.

Phase of Ons[illegible] [illegible] mild feverish illnesses may be regarded as due t[illegible] ntrary is proved and treated accordingly. It cannot be told which cases are going to progress to paralysis and which are not. There are, however, *certain conditions* that are

known to increase the probability of paralysis and these must be avoided whenever practicable; the most important are fatigue and injury (and pregnancy). Paralysis often follows fatigue during the incubation period and it is the group or groups of muscles concerned that are likely to become paralysed. Thus the woman who uses a hand operated sewing machine during the febrile stage may suffer paralysis of the right upper limb, and the man who plays football may well develop quadriplegia. Some physicians regard the need for rest as being so important that they will not permit their patients to hold a book, or even feed themselves. Injury may also be followed by paralysis of the muscles of the same region; thus tonsillectomy may be followed by bulbar paralysis, and intramuscular injection by paralysis of the muscle injected. It has also been suggested that lumbar puncture is followed by an increased incidence of paralysis of the thigh muscles, but this is not proven.

After paralysis has developed rest is still the chief indication. Sedatives may be necessary for the relief of pain and to ensure rest. Aperients are required if constipation is troublesome but treatment should not be allowed to cause undue disturbance. The mattress must be firm, and if necessary supported by "fracture boards". Weak or paralysed limbs should be prevented from moving by sand-bags or light splints, the hips and knees being slightly flexed, the feet supported, and the shoulders abducted and in neutral rotation. At first rest is more important than accurate splinting and the latter can be postponed for a few days. Hot fomentations help to relieve muscle pain, but massage does more harm than good at this stage.

Paralysis of the respiratory muscles may require special attention. Atropine is given to diminish secretion. A mild degree of respiratory embarrassment can be alleviated by raising the head of the bed, but gross respiratory failure may develop very rapidly and the nurse should be warned that, if it does, artificial respiration must be commenced manually and continued without interruption whilst the patient is being transferred to a mechanical respirator.

Phase of Recovery. More active treatment is begun when the general symptoms have subsided but first it is essential to record accurately the precise extent of muscle weakness and paralysis. This is of importance in determining the prognosis and in deciding the earliest moment at which operative interference is desirable. It is not sufficient just to note, say, "foot-drop," but each muscle must be examined separately. The method of recording muscle power has been standardized in Great Britain by the Medical Research Council and this should always be used (p. 506). Progress must be charted at regular intervals.

SUPPORT. This is necessary to prevent deformity and to rest weak or paralysed muscles. The general requirements are that the support should be so arranged that paralysed muscles are held at an intermediate point in their range of movements, and that active and passive movements are possible without removing it.

The exact nature of the support varies with the extent of the paralysis. If it is widespread and includes the muscles of the buttocks, back or abdomen, a plaster bed is very satisfactory. It has the advantage of being able to accommodate all four limbs, it is comfortable, and it allows active movements of unparalysed muscles (Fig. 383). A single extremity without involvement of hip or shoulder is conveniently supported on a plaster shell.

The position in plaster plays an important part in determining subsequent function and must be arranged with meticulous care. The spine requires the same curves as when standing; the hips and knees should be slightly flexed, the ankles at right angles with the legs and the feet plantigrade, neither inverted or everted; the arms should be abducted about 70° in the scapular plane and in neutral rotation: the elbow is at a right angle, the wrist is slightly dorsiflexed, the fingers are placed in the position of rest and the thumbs partly opposed. The arm of the child illustrated below is abducted too much.

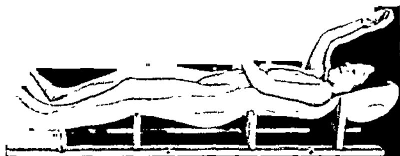


Fig. 383.

Movement. Commencing as early as possible, every joint should be gently moved once daily through its greatest painless range. This is an important feature of early treatment and has the object of preventing joints from becoming stiff and muscles from deteriorating.

Active contraction of affected muscles is encouraged but excessive fatigue must be avoided. At first a muscle may give a flicker once or twice but repetition is impossible until after a long rest; later it may move the joint whilst the weight of the limb is supported, and later still move it against gravity. Whatever the power of the muscle, exercise must be arranged to suit its strength, and it must be followed by a period of rest long enough to allow it to recover from fatigue. Trick movements should be watched for and care taken to encourage use of the proper muscles instead. Immersion in water during exercise is of great value because it counteracts the effect of gravity.

Co-ordination of movement and "awareness" of certain muscles appear to be lost in some patients, perhaps because of damage to communicating fibres within the spinal cord. Deliberate exercises in co-ordination may, therefore, be required. A muscle over which there is no direct voluntary control will sometimes contract when used as a synergist and advantage should be taken of this.

PASSIVE PHYSIOTHERAPY is of assistance in maintaining the nutrition of very weak or paralysed muscles. Muscles function better when warm than cold and therefore they may be gently heated before exercise. Massage improves both venous and lymphatic circulation but it should not be carried out roughly, nor for too long, or it may damage muscle fibres. Electrical stimulation may also be helpful. A paralysed muscle loses its response to faradism but reacts to galvanism and therefore interrupted galvanic stimulation is a useful form of exercise.

PROGRESS. No precise rules can be given as to the time when sitting up or walking may begin because of the great individual variation in the severity and distribution of paralysis. Every muscle with power less than that necessary to contract against resistance requires support until maximum recovery has occurred; this is difficult to arrange in an ambulant

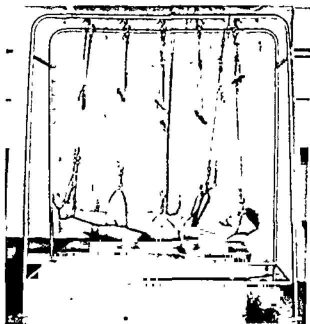


FIG. 384. Guthrie-Smith suspension frame.

patient, except when paralysis is limited in extent, and therefore many patients have to remain recumbent for several months. When only one lower limb is affected, however, walking may be possible fairly early using crutches and a light plaster splint; the upper limbs can be supported on splints or by means of a plaster spica; and the abdominal muscles must be protected by a well-fitting cloth corset if they show any sign of weakness.

Support for the trunk is very important when the erector spinæ are paralysed, especially in children, in order to prevent the development of scoliosis. There is no really efficient splint or jacket and therefore recumbency has to be continued for a much longer period. If a plaster bed is being used, a turning case should be provided to facilitate exercises.

Whether the patient is ambulant or recumbent, treatment under skilled supervision must be continued until maximum recovery has taken

place; this is often as long as two years and sometimes even longer. Exercise is carefully graduated to develop the weaker muscles. A swimming pool, or if this is not available, suspension by springs or by weights and pulleys, are of value when exercising weak muscles because the force of gravity is reduced (Fig. 384). It is most important to plan exercises with special regard to muscle balance because, if the patient is left to himself, he naturally uses the stronger muscles which then develop at the expense of the weaker ones, and imbalance is increased.

The final result, provided the destruction of nervous tissue is not too great, depends to no small extent on the perseverance of the patient. The way in which some apparently hopelessly paralysed people make use of the little power they have is so remarkable that it should never be forgotten by those in charge of them. The patient must not be allowed to despair however dreadful his disability may seem, but he must be treated in an atmosphere of encouragement and cheer, guided through the difficult early days, and taught to understand the way in which he can best help himself.

Deformity

Deformity can be caused by (1) overaction of unopposed muscles, (2) relative shortening of paralysed muscles and (3) weight-bearing on a partly paralysed limb. It should, however, seldom occur when treatment is carried out in proper conditions and is competently supervised, except perhaps at the spine which is difficult to support by mechanical means.

Some deformities, such as genu recurvatum, are associated with lengthening of the soft tissues and the joint is hypermobile. In the majority, however, the deformity is fixed by soft tissue contraction, and at a later stage by adaptive changes in the shape of the bones.

Spine. Scoliosis is a common sequel to weakness or paralysis of the muscles of the back or abdomen, particularly when unilateral. In children, the deformity tends to increase during growth and may become very severe. It is probable that "idiopathic" scoliosis is often due to undiagnosed poliomyelitis (p. 109).

Scoliosis is often rather late in developing and is easily overlooked in the early stages. Once the shape of the bones has changed it is impossible to correct it; prophylaxis is therefore most important and a spinal or abdominal support is necessary whenever the muscles of the trunk are involved. The support must be worn until growth of the spine has ceased at about fourteen years of age, and then spinal fusion may be considered. Developed scoliosis is treated in the same way as when it is due to other causes (p. 115).

Hip. Flexion-adduction deformity occasionally results from paralysis of the gluteus maximus, and when all the glutei are paralysed the hip may dislocate backwards. A mild degree of flexion deformity can be overcome by stretching, but a more severe contraction may require correction by *Soutter's fasciotomy.* In this operation the fascia femoris is divided and the muscles on both surfaces of the anterior portion of the ilium are detached subperiosteally and allowed to slide downwards. Dislocation of the hip

may be controlled by construction of an artificial check ligament (*Ober*), and several other operations.

Knee. Various deformities may occur. Flexion deformity due to overaction of the hamstrings and gastrocnemei can usually be straightened by traction or by a wedged plaster. Hyperextension due to weakness of the flexors is a serious disability; it is not satisfactorily treated by operation and a caliper may be necessary. Genu valgum is not uncommon, and if severe it may need correction by osteotomy (p. 34).

Foot and Ankle. Pes equinus, probably the commonest of all paralytic deformities, is due to paralysis or weakness of the dorsi-flexors of the foot and relative overaction of the calf muscles. The deformity is easily corrected by lengthening the tendo-Achillis but this must not be done if the knee is unstable. Many patients whose quadriceps are paralysed can walk without apparatus by bracing the leg against an equinus foot.

A cavus deformity develops when the triceps suræ are paralysed and the tibialis anterior together with the long flexors and the invertors or evertors of the foot remain in action. The severe degrees are most difficult to correct, even at operation, and every effort should be made to prevent them. There is some evidence that they may be at least reduced in severity by tendon transfers designed to provide a better balance of the muscle power available. Stabilization should, however, be performed as soon as practicable.

A valgus or varus deformity occurs either alone or in conjunction with equinus or cavus as a result of an unequal degree of weakness of the invertors and evertors. A valgus position is also assumed by a flail foot when bearing weight. Tendon transfers have only a limited application as an adjunct to other operations, and occasionally to restore the balance of the foot when only a single muscle remains paralysed.

Upper Limb. Fixed deformities, except at the shoulder, are seldom seen and they do not conform to standard types. Adduction-internal rotation deformity of the shoulder is sometimes troublesome and may be overcome by repeated passive stretching or by operation (p. 526).

Residual Paralysis

The assessment of a patient at this stage is a responsibility needing a wide knowledge both of the mechanics of the human body and of the many different kinds of stabilizing operations and apparatus. Maximum motor recovery has taken place, or at any rate the possibilities of further improvement are defined, and the problem is to enable the patient to make the greatest possible use of the remaining muscle power.

It is not always necessary to await maximum recovery before embarking on stabilizing operations provided the patient is old enough for arthrodesis to be practicable. A muscle that shows no recovery or only a flicker of movement after, say, six months is unlikely ever to become strong enough for heavy work and it saves the patient's time to arrive at an early decision. For example, if the invertors of the foot are paralysed, the foot goes into extreme valgus when standing and the sooner it is stabilized

the better because the immediate improvement in function enables the patient to concentrate on other and more difficult problems. But if the muscles of the hand are weak, the decision to operate should be postponed for as long as there is hope of improvement.

Three methods of stabilizing joints and redistributing muscle power are available for use separately or in combination—*apparatus, arthrodesis* and *tendon transplantion*. Much ingenuity has been displayed in evolving different uses for tendon transplantation, and although they are of great value for an occasional patient, few have proved successful enough for general service. In Great Britain the use of transplants is more or less

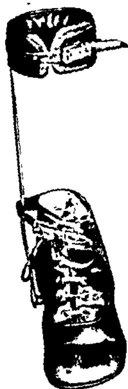


FIG 385 Short inside iron and outside T-strap to control pes varus.

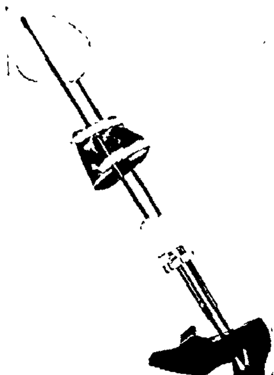


FIG 386 Long double irons with round socket in heel and ankle stop at 90°.

restricted to the hand; for the lower limb arthrodesis is more popular because it usually gives a better functional result.

Detailed description of the many possible procedures is outside the scope of this book and only the general lines of some of the commoner ones will be indicated.

Spine. The approach, whether by apparatus or operation, is similar to that for scoliosis in general but the paralytic spine is more easily supported by apparatus (p. 115).

Hips, Knees and Feet. *Bilateral.* Almost every patient whose arms are good enough to use crutches can be made ambulant, even when there is complete paralysis of both lower limbs. The knees are held straight by long double irons with an ankle stop to control foot drop (Fig. 386), if the

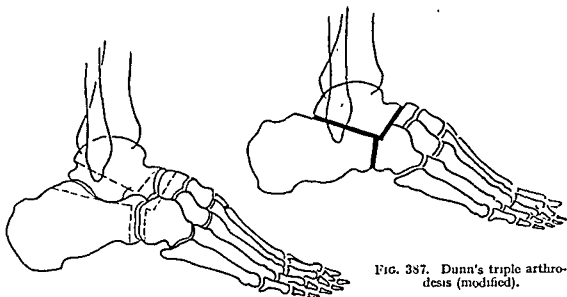


FIG. 387. Dunn's triple arthrodesis (modified).

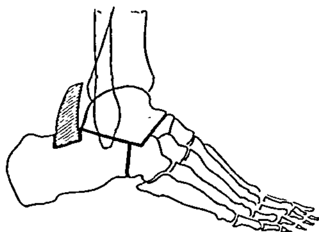


FIG. 388. Campbell's bone block for foot drop.

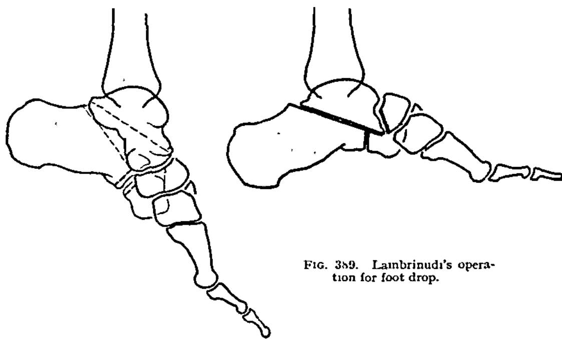


FIG. 389. Lambrinudi's operation for foot drop.

spinal muscles also are weak, a spinal support is provided, and then "tripod" walking is possible with the aid of two crutches. *Progression by this method* is slow, but at least it is possible for the patient to get about the house alone. Stabilizing operations are seldom worth while.

Unilateral. Absence of the glutei causes a gross "Trendelenberg limp" which is very difficult to prevent (p. 144). Leg irons can be attached to a pelvic band or spinal support by means of a hinge at the hip, but this is seldom satisfactory. Arthrodesis of the hip does not give good function unless the quadriceps are strong. As a rule, when the knee and ankle are flail as well as the hip, it is best to accept the limp and control the knee and foot with irons. Occasionally *Ober's operation* may be feasible; the fascia femoris is detached at the lower end, passed through a hole cut in the upper end of the femur and attached to the erector spinae which are thus enabled to act as abductors of the hip.

Knee and Foot. The gait, if only one leg is affected, is reasonably good when the knee and foot are controlled by irons. It is often possible, however, to dispense with apparatus, even when both legs are involved, by stabilizing the foot in equinus (see below).

Knee. Paralysis of the quadriceps causes surprisingly little disability provided there is some fixed equinus against which the leg can be braced. The glutei, when reasonably strong, are used to brace back the thigh thus fixing the knee, and there is hardly any limp; when the glutei are weak, the trunk is thrown a little forwards when walking and then the knee is forced backwards and locked because the centre of gravity of the body is in front of the joint (*Fig. 4, p. 7*). Although it is unusual for apparatus to be necessary when only the knees are affected—I have a patient with bilateral flail knees and stabilized feet who dances excellently—sufficient stability cannot always be acquired without assistance and then leg irons with a knee hinge and lock can be supplied. With unilateral paralysis arthrodesis of the knee is sometimes desirable. Transfer of the hamstrings to the extensor mechanism has often been tried but it has seldom proved to be worth while.

Paralysis of the hamstrings in the presence of good quadriceps is difficult to deal with and often necessitates the use of apparatus.

Foot. Stabilization of the foot is a really satisfactory operation giving good function and practically no limp. It is indicated when there is paralysis of the invertors causing a valgus foot, paralysis of the evertors causing a varus foot, and when the foot and ankle are flail.

The several operations in common use are all based on the classical prototypes described by Dunn in England and Hoke in the U.S.A. *Dunn's operation* is a triple arthrodesis in which the talo-calcanean and calcaneo-cuboid joints are fused and the entire navicular is removed, the talus being joined to the cuneiforms. Most surgeons prefer not to remove the navicular and fuse the talo-navicular joint instead (Fig. 387). The same object may be achieved, provided the ankle is not flail, by the more modern method of fusing the joints with cancellous grafts.

When the ankle is flail Dunn's operation requires modification in such

a way as to limit foot drop and yet permit dorsi-flexion at the ankle. The desirable range of movements depends on the height of heel customarily worn and on whether the knee is flail; in the latter case some fixed equinus must be provided. *In Lambrinudi's operation a wedge of bone of the* required size is excised from the talus and calcaneus and this enables the necessary range of movements to be provided with accuracy (Fig. 389.)

Other procedures having the same objective, such as *Campbell's operation*, involve first a triple arthrodesis, and then checking foot drop by a bone graft inserted into the posterior end of the calcaneus (Fig. 388).

Upper Limb. The value of the upper limb depends principally on the function of the hand, and as long as movement of one finger remains, the hand can be made of some use. It is, however, necessary for the hand to be moved to the object to be grasped and therefore, if the shoulder and elbow are flail, they must be stabilized.

Shoulder. Arthrodesis is a most useful operation when the muscles controlling the scapula are reasonably strong (p. 338).

Elbow. Transfer of the lower fasiculi of the pectoralis major to replace the flexors of the elbow (*Clark's operation*) is a valuable procedure and can give really useful power.

Stabilization may be effected either by arthrodesis or by an arm corset with a hinge that enables the joint to be locked in any position (Fig. 265, p. 353). Arthrodesis is usually more satisfactory when the muscles of the shoulder are strong enough to control it, but a corset is better when the shoulder has been arthrodesed.

Hand. The possibilities depend on the available muscle power. The essential requirements are active flexion of at least one finger, preferably the forefinger, and a "post" against which the finger can press. If all the flexors of the fingers are paralysed, it may be possible to supply motor power by transplanting one of the flexors of the wrist. The best "post" is an opposable thumb, and if a suitable muscle is available, a tendon transplant can be performed to provide active opposition; if no muscle is available, the thumb may be fixed in opposition by means of a bone graft placed between the first and second metacarpals. It may be desirable to arthrodese the wrist in slight dorsi-flexion (p. 379). When paralysis is limited to the intrinsic muscles and there is a claw hand, *Bunnell's operation* is successful (p. 377).

Resettlement

Sufferers from poliomyelitis are remarkable for the fortitude with which they face their problems and overcome their physical disabilities. It is rare for residual paralysis to be so widespread as to leave the individual quite helpless. Most people, by learning to do the ordinary things of life in a different way from others, are able to look after themselves and earn a living or run a home. Children, for the most part, adapt themselves naturally. Adults may need encouragement, help and sometimes special training; treatment is not finished until the patient is back at work.

SPASTIC PARALYSIS

(*Synonyms*) Little's Disease, Cerebral Paralysis of Children, Cerebral Diplegia, Congenital Diplegia

Paralysis is a misnomer. The term "spastic paralysis" is applied to a heterogenous group in which there is disturbance of the locomotor system with hypertonia of the muscles, occasionally hypotonia, often athetosis, but never paralysis. The condition is present at or soon after birth and is due to a lesion of the cerebral cortex or basal ganglia causing a disorder of upper motor neurone type. The precise symptoms vary with the extent and distribution of the lesions and include spasticity, involuntary movements and mental defects.

Different names are applied according to the region affected :—

One extremity.	*Monoplegia.*
Half the body.	*Hemiplegia.*
Both legs.	*Paraplegia.*
Both legs and arms.	*Diplegia* or *quadriplegia.*

The ætiology has been much disputed. Of the several theories advanced at different times, the following are usually accepted :—

ANTE-NATAL—Rare. Early arrest in fœtal development.

NATAL—Common. Birth injury causing meningeal hæmorrhage is probably the cause in most instances.

POST-NATAL—Uncommon. Thrombosis, meningitis, or encephalitis.

Clinical Features

The symptoms vary with the distribution of the degenerative changes in the brain. They fall into four distinct groups which, however, are often mixed.

PRE-FRONTAL CONVOLUTIONS. Mental defects which vary in degree from slight backwardness to idiocy.

PRE-CENTRAL CONVOLUTIONS. Defects of motility. There is spasticity of the lower limbs and often of the upper limbs also. Very occasionally there is hypotonia affecting the limbs, the back and the neck.

BASAL GANGLIA. Uncontrolled athetoid movements of the affected limbs, usually more marked in the arms than the legs. Athetosis is exaggerated on attempting voluntary movements and during emotional stress, and it is usually absent during sleep.

CEREBELLUM. Rare. Ataxy of cerebellar type.

Phelps has drawn attention to a condition of pseudo-spasticity, or "athetosis with tension," which occurs as the result of spontaneous efforts to control involuntary movements. The limbs are held rigid in the attempt to keep them still and, in the course of time, a condition develops which is indistinguishable on casual examination from true spasticity. The differential diagnosis between true spasticity and athetosis with tension,

a way as to limit foot drop and yet permit dorsi-flexion at the ankle. The desirable range of movements depends on the height of heel customarily worn and on whether the knee is flail; in the latter case some fixed equinus must be provided. In *Lambrinudi's operation* a wedge of bone of the required size is excised from the talus and calcaneus and this enables the necessary range of movements to be provided with accuracy (Fig. 389.)

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with difficulty. Such children are usually amiable, but emotionally unstable and erratic ; in some instances the defect is so severe as to amount to idiocy and the child is unable even to sit up properly.

Accurate estimation of intelligence is of great importance but it is difficult because the physical defects may interfere with routine tests. Only the more intelligent respond well to treatment which is both elaborate and lengthy. The intermediate grades can usually be taught to walk and look after themselves by comparatively simple measures, but they do not benefit from more advanced education ; the least intelligent are not proper subjects even for surgical treatment.

Diagnosis

During the first three months of life nothing abnormal is noticeable unless there is gross mental defect and then development is retarded in all fields. The infant is late in loosing the early reflexes and late in acquiring new ones such as lifting the head, sitting up and crawling. This does not, however, assist greatly with diagnosis because it applies equally when there is mental retardation without cerebral palsy ; the latter cannot be recognized with certainty until later.

With minor degrees of palsy without gross mental defect, the sequence of development is normal but an observant mother may notice an abnormality in the pattern of spontaneous movements of the limbs, or a slight stiffness of one or both legs when she is washing the child. When the arms are affected the grasp reflex is strong and the hands may be held firmly clenched. The child also is slow in approaching his hand to an object he wants, and in opening the fingers to grasp it.

In more severe affections spasticity may be demonstrated by lifting the infant by the axillæ ; the normal child draws up the legs, but the spastic extends and perhaps crosses them. Spasticity in older children is recognized by the characteristic resistance to passive flexion ; there is difficulty in commencing the movement, but the spasm suddenly gives way and the rest of the range is free. Involuntary movements often do not appear until two or three years of age.

In spastic paralysis of spinal origin, which also may be the result of birth injury, the affection is bilateral and symmetrical. There is usually pain at some stage, impairment of sensation, and often trophic changes in the limbs.

Treatment

Non-operative. Little change has been noticeable in our conception of spastic paralysis, or in its treatment, since the time over 100 years ago when W. J. Little, who took so much interest in the disease, himself underwent a tenotomy (for club foot). Since then it has been customary to correct deformities by tenotomy, and more recently, with the intention of reducing the power of muscles in spasm, by neurectomy also ; re-education filled only a secondary rôle. This attitude has been challenged by Phelps of Baltimore who has shown that many patients are not suffering from true spasm of pyramidal origin, but a state of "athetosis with tension" which is

which is most important because the prognosis is better in athetotics, is discussed under treatment.

Spasticity. The distribution is usually symmetrical and more marked in the lower than the upper limbs; occasionally it is greater on one side of the body than the other. The tendon reflexes are generally increased and the plantar responses upgoing. The affected limbs are held rigid, often in a distorted position, and they are used with difficulty even when muscle power is reasonably good. The degree of spasticity varies from slight awkwardness in the use of the limbs to gross rigidity in which voluntary movement is impossible.

The appearance when well developed is characteristic (Fig. 390). The lower limbs are held with the hips flexed, adducted and usually internally rotated, the knees may be extended or partly flexed, and the feet are in equinus. When both legs are affected the knees are pressed together, or one leg is crossed over the other, making walking very difficult (scissors gait). The upper limb in a severe case is held with the shoulder adducted and internally rotated, the elbow flexed, the forearm pronated, the thumb opposed and the fingers flexed over the thumb. Lordosis is common because of flexion of the hips and spasm of the erector spinæ, and there is often some scoliosis because the power of the spinal muscles of the two sides is unequal. The face may be expressionless, and in a hemiplegic it is asymmetrical.



Fig. 390. Spastic paralysis showing "scissor legs" and athetoid movements of the hands.

Athetosis. Athetoid movement is present in at least a quarter of all patients, and probably in many more because of the frequency with which it is masked by muscle tension. It is usually more marked in the arms than the legs, and it is more in evidence when there is little spasticity. The arms are affected by slow, sinuous twisting movements, irregular, arrhythmical and of considerable range. The movements are worse when attempting to control them and during deliberate voluntary actions. If the legs are affected, it is difficult to place the feet accurately when walking and the gait is unsteady. Speech may be disturbed, deglutition uncertain, and even when the face is ordinarily expressionless, there may be attacks of involuntary laughing or crying.

Mental Development. There is frequently some degree of mental impairment although it may be comparatively slight and interfere but little with education. Unfortunately the mental defect is often more serious and many children can be taught to walk and keep themselves clean only

particularly of the foot and knee, can often be corrected by wedged plasters as described by Kite for the treatment of club foot (p. 310), and this should be tried before proceeding to operation.

There are three types of operation in common use—tenotomy to correct contractures, neurectomy to reduce the power of spastic muscles, and sometimes arthrodesis.

c muscle

position

even when the muscle is relaxed. It is of less value when there is a good range of movement during relaxation because continued spasm eventually "takes up the slack," and the deformity returns. During examination spasm can usually be overcome by *firm steady pressure, but deep anæsthesia* is sometimes necessary to obtain full relaxation. The periarticular tissues may be contracted and require division as well as the tendon.

The usual deformities to require correction are :—

Equinus Deformity of the Foot. Lengthening the tendo-Achillis by open operation gives more consistent results than closed tenotomy. The posterior capsule of the ankle joint may also require division. Stabilization by triple arthrodesis may be required for equinovarus.

Flexion Contracture of the Knee. This can be corrected by lengthening the hamstrings and, if necessary, posterior capsulotomy (p. 228).

Adduction of the Hip. The adductors are readily tenotomized close to their origin from the pelvis.

Internal Rotation of the Hip. If adductor tenotomy gives insufficient correction, the gluteus medius and tensor fascia femoris may be detached from the ilium and allowed to slide lower down. Arthrodesis is sometimes desirable when there is a unilateral deformity.

Internal Rotation of the Shoulder. Benefit is sometimes derived from division of the pectorals, and in very severe deformities division of the subscapularis also.

Flexion of the elbow. Tenotomy or lengthening of the biceps and brachialis muscles is sometimes practised.

Flexion of the wrist may, if necessary be corrected by arthrodesis.

NEURECTOMY (*Stoffel's operation*). This aims at restoring muscle balance by dividing all or some of the motor fibres supplying a spastic muscle. Although at one time it was widely practised for spasm of the hamstrings, the calf muscles and the muscles of the forearm, it is now going out of favour for all regions except the adductors of the hip.

Obturator neurectomy often materially improves both comfort and gait. The entire nerve can safely be divided because it supplies only part of the adductors ; there is sufficient power of adduction in the remaining parts which are supplied by branches of the sciatic and femoral nerves.

The obturator nerve is conveniently exposed by an extra-peritoneal approach and divided as it lies on the inner wall of the pelvis before entering the obturator foramen. It can also be exposed by dissection in the groin where the anterior branch, the posterior branch, or both may be divided.

distinguished from it only with difficulty. Mental defects are usually less severe in this group, the prognosis is rather better, and comparatively few cannot be educated.

Treatment cannot restore children to normal, but many become independent and economically self-supporting and therefore it is generally worth-while, whether athetotic or true spastic symptoms predominate, provided there is a good or fair level of intelligence. Evans estimates that 90 per cent of children with athetosis in tension are educable, but only 10 per cent of true spastics.

The presence of athetosis with tension becomes apparent during treatment because conscious relaxation, which plays an important part in it, releases the involuntary movements. Once incorrect muscle control has been acquired, it is hard to eradicate it. Some workers in this field therefore begin treatment very early, even at six months, if a diagnosis has been made at so young an age. The aim is to develop a proper motor pattern by giving the appropriate stimuli throughout the day and for this the mother's co-operation has to be enlisted.

Older children should be segregated in a special institution during treatment because the emotional atmosphere is controlled, and because it is necessary to have the co-operation of many special workers who can hardly be made available except in an institution. The therapeutic team is headed by a medical officer and consists of physiotherapist, educational psychologist, occupational therapist, speech therapist and teacher. It is said that ideally the number of staff should be several times greater than the number of patients. Parents of patients may be encouraged to take a place in the life of the community and so become familiar with the methods and continue the training after discharge.

The feature of prime importance is the acquisition of the power of conscious and voluntary relaxation. Relaxation is at first learned lying down, and then with gradual progression to sitting, standing with support and finally walking. Movements, for example feeding, are made during relaxation without regard for the interference caused by involuntary movements. Advantage is taken of the reflex inhibition of an antagonist muscle which occurs during active contraction of the agonist. Muscle control is learned gradually as confidence is gained, and the weaker muscles, for example the abductors and external rotators of the hips and the supinators of the forearm, are deliberately developed. Exercises are more readily performed if carried out rhythmically.

When there is true spasticity joint movements are so graduated as to avoid stimulating a stretch reflex which induces a return of spasm, and in time the range gradually increases. Massage and passive stretching of the muscles are directly contra-indicated as they tend to increase spasm.

Operative. Non-operative measures give the best results in selected patients, but a great many are in an intermediate group and are neither intelligent enough to benefit from elaborate education, nor of so low a grade as to be untreatable. Most of these can be helped by simple educative measures along the general lines already described. *Fixed deformity,*

OBSTETRICAL PARALYSIS

This is an unfortunate complication of child-birth in which there is partial or complete palsy of one arm, and rarely of both arms. It is caused by injury to the brachial plexus, a finding that has frequently been confirmed at operation. When the head is inclined and rotated to one side, the brachial plexus of the opposite side is stretched. Injury occurs, usually during the course of a difficult or prolonged labour, as the result of traction on the head, trunk or arm whilst the neck is bent sideways and twisted. The percentage of breech presentations complicated by obstetrical paralysis is higher than the percentage of head presentations, but since head presentations are much more common, the total number of obstetrical paralyses following them is four times as great as after breech presentations.

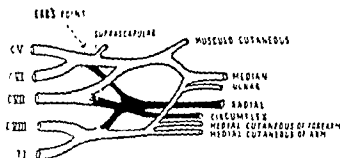


FIG. 391. The brachial plexus.

Damage to the brachial plexus may be of any degree of severity. In the less severe injuries, the nerve fibres are damaged in continuity and considerable recovery is probable (*axonotmesis*), but in the most severe injuries the nerve trunks are ruptured completely, or the nerve roots are avulsed from the spinal cord, and there is no possibility of spontaneous recovery (*neurotmesis*). Many injuries are of intermediate severity, some of the nerve bundles being damaged in continuity, and some being ruptured; partial recovery is then likely, but perineural hæmorrhage and subsequent scar formation may exert sufficient pressure on the plexus to prevent extensive regeneration.

Types

Three types are described, but they are often mixed.

Upper Arm (*Erb-Duchenne*). At least three-quarters of all obstetrical palsies are of this type. The injury is at the junction of the anterior primary divisions of the fifth and sixth cervical roots (Erb's point, Fig. 391). The muscles chiefly affected are the deltoid, supraspinatus, infraspinatus, teres minor, part of the pectoralis major, the biceps and the supinator longus, and sometimes the extensors of the wrist and fingers.

Lower Arm (*Klumpke*). This type is rare as an isolated occurrence. Only the eighth cervical and the first dorsal roots are involved, and the muscles affected are the flexors of the fingers and the intrinsic muscles of the hand. In addition, the sympathetic nerve fibres may be damaged

ADULT HEMIPLEGIA

Adults with hemiplegia of cerebral origin only too frequently lie around in institutions or in their own homes without treatment, and they rapidly develop crippling contractures and lose all interest in life. The condition in many respects resembles spastic paralysis of children and, up to a point, it is amenable to similar treatment. Much can be done by painstaking re-education; it is possible with a little trouble and a small expenditure of money (which in the United Kingdom can be defrayed by the Local Authority) to adapt a kitchen and its utensils in such a way as to enable a hemiplegic woman to manage much of her domestic work.

Operative correction of contractures may be helpful, especially in younger patients; it should not be unduly delayed or trophic changes may develop and the general condition deteriorates. Neurectomy is not usually practised, but tendon lengthening and joint stabilization may be of great value. The deformity most frequently requiring correction is pes equinovarus for which lengthening of the tendo-Achillis and triple arthrodesis may be performed (p. 515). Both operations can be carried out at the same time and it is often possible to restore useful function to an otherwise bed-ridden or chair-ridden patient.

THE HEREDITARY ATAXIAS

This group of diseases, of which *Friedreich's ataxia* is the commonest, is due to sclerosis of the posterior and lateral columns of the spinal cord. In some families the disease breeds true and one parent and some of the offspring have an identical affliction, but in other families the manifestations and course are different even in the same generation.

The age at onset varies from early childhood to early adult life. The severity of the disease also varies from a minor difficulty in co-ordination to complete incapacity. The principal symptoms are ataxia due to muscular inco-ordination which causes an irregular swaying gait, choreiform movements of the arms, and nystagmus. The tendon reflexes disappear, the ankle jerks usually being lost before the knee jerks, and the plantar responses are upgoing. The limbs may be hypotonic or slightly spastic.

The orthopædic interest is chiefly in the deformity of the feet which occurs when the pyramidal tracts are involved. The characteristic deformity develops early, often before the deep reflexes have changed. It consists of pes equinus with a superimposed pes cavus and clawing of the toes, especially the big toes. Scoliosis is present in a few patients when the muscles of the trunk are affected to a different extent on the two sides.

Operative correction of the deformity of the feet is more satisfactory when the onset is early than when it is late. The tendo-Achillis usually requires lengthening, and Lambrinudi's arthrodesis of the interphalangeal joints of the toes, if performed not later than fourteen or sixteen years of age, may prevent pes cavus developing (p. 269). When the onset is late, the patient may have to be content with surgical shoes and appropriately moulded insoles.

Some recovery often takes place during the first few months; it is usually gradual, occasionally rapid, and only rarely is it complete. Contractures develop rather quickly because of the unbalanced action of the muscles, and the shoulder becomes fixed by contraction of the subscapularis and anterior portion of the capsule in a position of adduction and internal rotation. In time the head of the humerus may subluxate backwards over the rim of the glenoid fossa and then the shoulder is partly flexed and the arm adducted across the chest. When the forearm extensors are paralysed, the wrist and fingers are held strongly flexed and the hand is useless.

Treatment

Conservative. Time must be given to allow the greatest amount of spontaneous recovery to take place, but contractures must be prevented meanwhile and therefore the arm is placed in a position of abduction and external rotation. This is most easily and safely arranged in very young

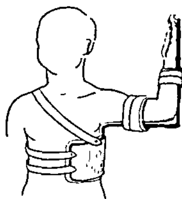


FIG. 393

babies by tying the wrist with a flannel bandage behind the neck to the opposite shoulder. This method can be used until the baby is sitting up and then a splint may be substituted. Temporary splints can be home-made from Kramer wire, but for older children an aluminium splint is preferable (Fig. 393). The splint is taken off each day when the baby is washed and the limb is moved to prevent stiffness. The use of a splint is continued, at any rate for part of the day, for two or three years, and thereafter regular passive movements through the full range should be sufficient to prevent contractures.

If there has been some recovery, much can be done to improve function by encouraging the use of the limb, particularly of the weaker muscles. The child often has the muscle power to make a particular movement but does so in an uncertain manner because of deficiency in proprioceptive sensibility. He therefore prefers to do most things with the unaffected hand alone and it requires no little ingenuity, and the utmost patience on the part of parents and physiotherapists, to devise entertaining ways of persuading him to use the affected limb. Some children tolerate having

causing narrowing of the palpebral fissure and reduction in the size of the pupil.

Whole Arm. The entire brachial plexus is ruptured, the arm is flaccid and there is complete sensory loss.

Clinical Features

Injuries of the upper arm and whole arm types are usually noticed soon after birth, but in lower arm palsies the most obvious sign is loss of the "grasp reflex" and this may be overlooked for a time.

Upper Arm. In a classical example of upper arm paralysis the arm lies with the shoulder adducted and rotated inwards, the elbow extended,



Fig 392 Obstetrical palsy of upper arm type

the forearm pronated, and the palm of the hand facing backwards (Fig. 392). Spontaneous active movements are conspicuously absent, and passive movements of the shoulder are painful. There is tenderness above the clavicle, and sometimes a swelling due to hæmorrhage. The differential diagnosis is from fracture of the humerus or clavicle, and separation of the upper epiphysis of the humerus.

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the good hand tied to the body part of the time, but this should not be done if it is seriously resented; it causes less upset if started very young, a few months after birth. Galvanic stimulation of the paralysed muscles is probably worth while for as long as improvement continues.

Operative. Repair of the brachial plexus has been attempted many times but only on rare occasions has it been rewarded with a worth-while result. The nerve ends are frayed and ragged, and even if they can be approximated, the amount of perineural scarring is usually so great as to prevent regeneration. Operation is unnecessary if there is appreciable spontaneous recovery; if there is no recovery after a year or two and the paralysis is extensive, exploration may be justifiable because it offers the only hope of improvement.

Contractures at the shoulder in infants can usually be corrected by manipulation under anaesthesia followed by fixation in a plaster-of-Paris spica. In older children, particularly when the function of the hand is good, open division of the contracted tissues may be desirable. In *Fairbank's operation* the shoulder is approached through an anterior incision and the tendon of the subscapularis muscle and the joint capsule are divided; sometimes it is necessary to divide also the teres major and latissimus dorsi, and occasionally a "beaked" acromial process requires removal.